



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

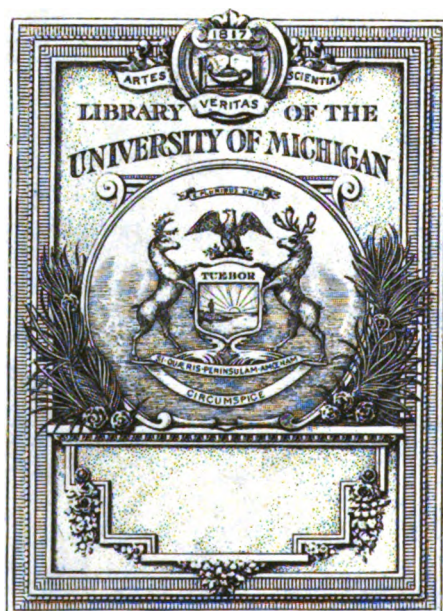
- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

B 478163

DUPL



Science Library

Q

11

.W538

.B7

The WEST VIRGINIA SCIENCE Bulletin

**VOL. I.
NO. I.**



**May
1922**

EDITORIAL NOTE

SCIENCE FACULTY LIST

LIST OF BULLETINS OF WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION.

RESEARCH IN ENGINEERING

—R. P. Davis

THE UNSOLVED PROBLEMS OF MEDICINE

—Aaron Arkin

SOME UNSOLVED PROBLEMS IN PHYSICS

—C. W. Waggoner

PLANT DISEASE PROBLEMS IN WEST VIRGINIA

—N. J. Giddings

**Published by the West Virginia University Scientific Society,
Morgantown, W. Va.**

THE WEST VIRGINIA SCIENCE BULLETIN

Published quarterly by

THE WEST VIRGINIA UNIVERSITY
SCIENTIFIC SOCIETY

Morgantown, W. Va.

Editor Aaron Arkin

Associate Editors { C. W. Waggoner
R. P. Davis
N. J. Giddings

Volume 1	May, 1922	Number 1.
----------	-----------	-----------

CONTENTS.

	Page
<i>Past Presidents, and Officers for 1921-22</i>	3
<i>Editorial Note</i>	5
AARON ARKIN	
<i>Science Faculty List</i>	9
<i>Bulletins Published by the West Virginia Agricultural ex- periment Station</i>	41
<i>Research in Engineering</i>	47
ROLAND P. DAVIS	
<i>The Unsolved Problems of Medicine</i>	59
AARON ARKIN	
<i>Some Unsolved Problems in Physics</i>	72
C. W. WAGGONER	
<i>Plant Disease Problems in West Virginia</i>	78
N. J. GIDDINGS	



WEST VIRGINIA UNIVERSITY SCIENTIFIC SOCIETY

PAST PRESIDENTS

A. R. Whitehill.....	1914-15
S. B. Brown.....	1915-16
F. E. Emory.....	1916-17
C. W. Waggoner.....	1917-18
B. H. Hite.....	1918-19
A. M. Reese.....	1919-20
Aaron Arkin.....	1920-21

OFFICERS FOR 1921-22

President.....	N. J. Giddings
Vice-Pres.....	R. P. Davis
Secretary.....	G. S. Dodds
Treasurer.....	F. E. Chidester
Program Committee	{ C. W. Waggoner
	{ Aaron Arkin
	{ G. S. Dodds

EDITORIAL NOTE.

Last year the President of the West Virginia University Scientific Society, realizing the need of fostering research work at this institution, appointed a committee to study this problem and report its findings to the Society. After a number of meetings, at which all of the science departments of the University were represented, a report was submitted by the head of each department giving the needs of his department for the promotion of graduate and research work. These reports furnished many interesting discussions, and may some day be published. The need of a graduate school with a dean, and of a medium for the publication of the results of research work, were chiefly emphasized by the committee.

The result of the deliberations of this Committee on Scientific Work and Publication, was the drafting of resolutions submitted at the meeting held on May 20, 1921, as follows:—

To the President of the University:

We, the undersigned members of the West Virginia Scientific Society, desire to present to you some resolutions growing out of a number of conferences and meetings of the science men in this University.

We need not call your attention to the two-fold function of the University—i. e. teaching and research—that the real university must have both—but the results of our study lead us to conclude that the research work has not kept pace with the teaching function in our institution.

We recognize this condition of affairs is very common in growing state universities and we find the following to be some of the needs of our University that stand in the way of its development in research.

1. All the science departments report that the library is notably deficient in scientific journals and special texts. We therefore hope that appropriations for the Library will be made just as liberal as possible.

2. Practically all state universities issue a quarterly Bulletin giving a medium for the dissemination of the results of the scientific work of the institution. The University already supports the Agriculture and Law Bulletin and we feel that the scientific work of this university well merits a Science Bulletin and the Society would be very glad to appoint from its membership an editorial board to conduct the Bulletin if such can be arranged for.

3. To relieve the heads of departments and professors from a large amount of paper grading, preparation of laboratory material and work of this nature so that men who have the training and the inclination may devote more time to productive scholarship, we recommend that a larger number of graduate student assistantships be instituted. We need not point out to you that this serves not only the purpose mentioned above but at the same time makes an opportunity for many worthy students to pursue advanced studies and it will attract many a worthy young man and woman to the teaching profession.

4. We further feel that the time has come in the history of our University for the organization of a graduate school. We feel that the liberal support which the people of the state have given in the acts of the last legislature point to a larger life for this institution. Many of the needs above mentioned will be served by the complete organization of the graduate school on the same basis as the other schools of the university.

Be it therefore resolved: 1. That it is the sense and judgment of the West Virginia Scientific Society that this University should have a graduate school organized on the same basis as the other schools of the University.

2. In appointing a man as Dean of Graduate School, we trust that due consideration will be taken of the man's productive scholarship. He should be a man who not only has an interest in research but who has carried to successful completion some original investigation.

3. It has been suggested that if no funds are available for this work that the university fees paid by the members of the senior class be set aside for use in the promotion and advancement of the graduate school.

4. That these resolutions be presented to the President of the University with the recommendation that such school be or-

ganized so that it may begin its work at the beginning of the next semester.

Respectfully submitted,

Committee

J. L. Coulter
G. S. Dodds
N. J. Giddings
F. E. Clark
C. W. Waggoner

A. M. Reese
H. H. York
R. P. Davis
J. L. Tilton
J. A. Eisland

AARON ARKIN, *Chairman.*

The newly elected President of the Society then appointed a Committee on Publication of a bulletin for the Scientific Society. President F. B. Trotter of the University endorsed this action and offered to have the printing of the bulletin done as a University publication. The Society also authorized the appointment of a Committee on Graduate Work consisting of the newly elected and out-going officers. This committee is to study the condition of graduate and research work in the University and aid in increasing facilities for such work and the establishment of a separate Graduate School in the University.

The first number of the Bulletin contains a list of the science faculty of the University arranged alphabetically. The data given under each name was obtained from a questionnaire, sent by the editor to each person. The information chiefly desired was the list of degrees and schools where they were obtained, previous university positions, memberships in national scientific organizations, and researches published. Not all of the questionnaires were returned, and in such cases, information was obtained from the University catalog, etc. It is hoped that subsequent publications of this list will make it more complete. To do this we need the cooperation of all the members of the science faculties.

AARON ARKIN,
Editor.

SCIENCE FACULTY LIST

(Note: The date following the position held indicates the year of appointment. The Morgantown Street address and telephone number follow each name.)

- ANDREWS, EDGAR LOUIS**, East Willey St. 880-M.
 Assoc. Prof. of Poultry Husbandry, and Assoc. Poultryman,
 Exp. Sta. (1913).
- ANGELO, ERNEST**, Richwood Ave.
 Instr. of Horticulture and Asst. Horticulturist, Exp. Sta.
 (1919).
 B. S., Agr., W. V. U., 1919.
 American Society for Horticultural Science.
- ANTHONY, ERNEST LEE**, State Dairy Farm, 514-R.
 Prof. of Dairy Husbandry and Head of Dept. of Dairy Husbandry, Exp. Sta. (1919).
 B. S., U. Missouri, 1912; M. S. Penn. State College, 1914.
 Asst. Prof. of Dairy Husbandry, Penn. State College, 1912-19.
 Dairy Science Assoc.
 Bulletin, Penn. Station, No. 135, 1915; Bulletin, W. Va. Station, No. 32, 1920.
- ARKIN, AARON**, 282 Grand St. 686-R.
 Prof. of Pathology and Bacteriology, (1913).
 B. S., U. of Chicago, 1909; M. A., U. of Wisconsin, 1910;
 M. D., Rush Medical College, 1912; Ph. D., U. of Chicago, 1913.
 Fellow in Physiology, U. of Chicago, 1909; Instr. in Pharmacology, U. of Wisconsin, 1909-10; Fellow in Pathology, Rush Medical College and U. of Chicago, 1910-12; Sprague Institute for Medical Research, 1913.
 American Medical Assoc.; West Virginia Medical Assoc.; American Assoc. of Pathologists and Bacteriologists; Society of American Bacteriologists; American Public Health Assoc.; A. A. A. S.; National Tuberculosis Assoc.; American Society for Control of Cancer; American Physiological Society; American Pharmacological Society; Chicago Pathological Society; Society of Sigma Xi; Honorary Member, W. Va. Pharmaceutical Assoc.; American Assoc. of University Professors; Southern Medical Assoc.; International Assoc. of Medical Museums; Congress of Physicians and Surgeons of N. A.
 On the antiseptic and bactericidal action of the sodium salts of iodbenzoic, iodosobenzoic and iodoxybenzoic acids. Jour. of Pharm. and Exp. Ther., 1911, 3, p. 145-146.
 The action on dogs of the toxic substance obtainable from pneumococci and pneumonic lungs. (With E. C. Rosenow), Jour. of Infec. Dis., 1912, 11, p. 480-495.
 The influence of strychnine, caffeine, chloral, antipyrin, cholesterol, and lactic acid on phagocytosis. Jour. of Infec. Dis., 1913, 13, p. 408-424.

- The influence of strychnine on phagocytosis. *Proc. Chicago Path. Soc.*, 1911, 8, p. 145.
- The influence of certain oxidizing agents (sodium iodosobenzoate and sodium iodoxybenzoate) on phagocytosis. *Jour. of Infec. Dis.*, 1912, 11, p. 427-432.
- The influence of an oxidizing substance (sodium iodoxybenzoate) on immune reaction. *Jour. of Infec. Dis.*, 1915, 16, p. 349-360.
- Recent advances in our knowledge of the infectious diseases, *Amer. Jour. of Public Health*, 1916, 6, p. 323-333.
- Acquired syphilitic ulcers of the bowel (Demonstration of the spirochaeta pallida). *Trans. of Chicago Path. Soc.*, 1912, Feb.
- Malignant disease of the retained testicle. (With A. P. Butt) *Surg., Gynec., and Obstet.*, 1914, Sept., p. 419-420.
- The Cancer Problem, *W. Va. Med. Jour.*, 1915, Dec.
- Recent Advances in our knowledge of the infectious diseases, *W. Va. Med. Jour.*, 1915, Oct.
- The work of the Hygienic Laboratory for the Physician and the Public Health. *W. Va. Med. Journal*, 1914, July.
- Report of the Bacteriological Department of the Hygienic Laboratory of the W. Va. State Board of Health (1914-15). Charleston, 1914, Biennial Report, p. 99-145, Charleston, 1916, Biennial Report.
- Information concerning the Hygienic Laboratory of the West Virginia Board of Health (Bulletin). Charleston, 1914.
- The Influence of an oxidizing substance (sodium iodoxybenzoate) on the catalase value of the blood and tissues. (With E. B. Fink) *Jour. of Infec. Dis.*, 1918, 22, p. 515-522.
- The tuberculocidal action of arsenic compounds and their distribution in the tuberculous organism. (Studies on the bio-chemistry and chemotherapy of tuberculosis XIV) *Jour. of Infec. Dis.*, 1916, 18, p. 335-348.
- Medical Science and the World War. *W. Va. Med. Jour.*, 1919, 12, p. 250-254 and 1919, 13, p. 295-300.
- The influence of Oxidizing substances on immune reactions. (Thesis presented at the U. of Chicago for the degree of Doctor of Philosophy, 1913).
- Clinical and Pathological Studies of Pandemic influenza. *W. Va. Med. Jour.*, 1919, 14, p. 121-125.
- Rat bite Fever—Report of Case. *Arch. Internal Medicine*, 1920, 25, p. 94-111.
- The Unsolved Problems of Preventive Medicine, *Amer. Jour. Public Health*, 1921, 11, p. 894-902.
- Work under way and in press:—Experimental cancer; Influence of some therapeutic agents on antibody produc-

tion; Simple goitre, its cause and prevention; The Control of Cancer; Focal infections and human disease.

ATWOOD, HORACE, 410 Charles Ave., 455-J.

Chief of Poultry Research, Exp. Sta., (1897).

B. S., Agr., Cornell, 1891; M. S., Agr., Cornell, 1897.

American Assoc. of Instructors and Investigators in Poultry Husbandry (formerly President); American Poultry Assoc., (Formerly Director); International Assoc. of Instructors and Investigators in Poultry Husbandry. (For two terms one of the three American Directors).

W. Va. Exp. Sta. Bulletins as follows:

109. Feeding Grain to Milch Cows on Pasture (Joint Author), 1907.
111. Bacteria in Milk and Artificial Refrigeration for Dairy men. (Joint Author), 1908.
112. Experiments with Fertilizers. (Joint Author), 1908.
115. Poultry Experiments—A Record of Six Hundred Hens. (Joint Author), 1908.
124. Some Factors Influencing the vigor of Incubator Chicks. (Joint Author), 1909.
129. Construction of a SMO, Author, 1910.
130. Construction of a Modern Poultry House and Reports of Experiments in Hopper Feeding Laying Hens. Author, 1910.
131. Plat Experiments with Fertilizers. Author, 1910.
134. Experiments in the Production of Sanitary Milk. (Joint Author), 1911.
135. West Virginia as a Poultry State. Author, 1911.
145. Some Factors affecting the Weight Composition and Hatchability of Hen Eggs. Author, 1914.
166. Certain characteristics of Hens' Eggs. (Joint Author), 1917.

DANCROFT, GEORGE RUSSELL, 23 Lincoln Ave. 654-J.

Assoc. Prof. of Chemistry. (1920).

B. A., Arcadia University, Wolfville, Nova Scotia, 1906; B.A., Yale, 1914; Ph. D., Yale Graduate School, 1917.

Prof. of Chemistry and Physics, Transylvania College, Lexington, Ky., 1917-18; Asst. Prof. of Organic Chemistry, U. of Kentucky, 1918-20; Assoc. Prof. of Organic Chemistry, W. V. U., 1920.

American Chemical Society; Kentucky Academy of Science; National Educational Assoc.; A. A. A. S.; American Assoc. of University Professors; National Geographic Society.

Preparation and Hydrolysis of Esters Derived from the Substituted Aliphatic Alcohols. Amer. Jour. Sc. 1917, 44, p. 371-380, and Jour. Amer. Chem. Society, March 1921.

- BARRETT, HAROLD JAMES**, 512 N. High St. 1062-J.
Asst. Soils Chemist, Experiment Sta., (1921).
B. A., W. V. U., 1919; M. S., W. V. U., 1920.
Asst. in Chemistry, W. V. U. 1917-18; Instructor in Chemistry, Iowa State College, 1920-21.
American Chemical Society.
- BEERS, CLAYTON LAWRENCE**, 66 Jackson St.
Asst. in Pharmacology, (1920).
Ph. G. Ferris Institute, Big Rapids, Mich., 1917.
Nat. Assoc. of Retail Druggists.
- BERG, ANTHONY**, 485 High St. 364-R.
Asst. in Plant Pathology, (1913).
B. S., U. of Wisconsin, 1912; and M. S., U. of Wisconsin, 1921.
Phytopathological Society of America.
- BERGY, GORDON A.**, 308 Park St. 1166-J.
Prof. of Pharmacy, (1916).
Ph. C., U. of Michigan, 1913; B. S., Pharmacy U. of Michigan, 1914; M. S., U. of Michigan, 1916.
Teaching Asst. U. of Mich., 1913-16; Health Service Pharmacist.
American Pharmaceutical Assoc.; American Chemical Society; W. Va. State Pharmaceutical Assoc.
- BONAR, MARTIN LOXLEY**, Morgantown. 7111-R4.
Prof. of Pharmacology, (1920).
B. S., W. V. U., 1913; M. S. W. V. U., 1915; M. D. Western Reserve University, 1919
Assoc. Prof. of Pharmacology, W. V. U., 1920; Prof. of Pharmacology, W. V. U., since 1921.
American Medical Assoc.
Effects of some New Local Anaesthetics. Jour. Pharm. and Exp. Therap. 1922, 18, 6, p. 467-489.
- BOOMSLITER, GEORGE PAUL**, 48 Willey Driveway. 571-J.
Prof. of Mechanics, (1920).
M. S. in C. E., U. of Illinois, 1914.
Instr. and Assoc., U. of Illinois, 1909-1920.
Soc. for Prom. of Eng. Educ.; Soc. for Testing Materials; Assoc. of University Professors.
- BRAGONIER, ARTHUR TAYLOR**, 118 Willey St. 221-J.
Instr. in Surveying, (1920).
B. S. C. E., W. V. U., 1916.
American Soc. of Civil Engineers; American Assoc. of Engineers.

BRAY, CHARLES MCHESNEY, 174 High St. 123.

Instr. of Physical Diagnosis, (1919).

A. B., D. and E. College, 1913; B. S., W. V. U., 1915; M. D., Western Reserve U., 1917

American Medical Assoc.; W. Va. State Medical Society.

The practical application of mercurochrome, 220, W. Va. Med. Jour., 1920.

BROWN, SAMUEL BOARDMAN, 640 High St. 796-J.

Prof. of Geology and Mineralogy, (1892).

A. B., W. V. U., 1883; M. A., W. V. U., 1886; A. A. A. S.

The Topography and Soils of West Virginia, 1907 (Published in the Agricultural Possibilities of West Virginia for the Jamestown Exposition).

The Geography of West Virginia, 1912. (Published as a supplement to Frye's Geography).

The Saltsburg Sandstone as a building stone. (Published in Science, May, 1918.

CALLEN, ALFRED COPELAND, 45 Jones Ave. 754-W.

Prof. of Mining Engineering, (1917).

E. M., Lehigh U., 1909; M. S. Lehigh U., 1911.

Instr. in Physics, Lehigh U., 1909-10; Instr. in Mining Engineering, Lehigh U., 1910-11; Assoc. in Mining Engineering, U. of Illinois, 1916-17; Instr. in Mining Engineering, U. of Illinois, 1914-16.

American Institute of Mining and Metallurgical Engineers. Coal Mining Institute of America.

Electric Locomotives for Coal Mines. Coal Industry, 1918, p. 103-107.

Storage Battery Locomotives in Mines. Coal Industry, 1918, p. 121-127.

Selecting Main Haulage Locomotives. Coal Industry, 1918, p. 245-248.

Determination of Latitude and Meridian. Coal Age, 1918, p. 168-170.

Educating Coal Miners in Subjects pertaining to Mining.

Vocational Summary, 1919, p. 15-17.

Educating the Adult in Mining Towns. Coal Industry, 1919, p. 69-73.

CATHER, C. H., 257 McLane Ave.

Instr. in Machine Design and Drawing, (1916).

B. S. M. E., W. V. U., 1916.

CATHER, H. M., 284 Second St.

Instr. in Machine Design and Drawing, (1919).

B. S. M. E., Texas A. and M. College, 1917.

CHIDESTER, FLOYD EARL, 24 Demain Ave. 280.

Assoc. Prof. of Zoology, (1919).

Ph. B., Syracuse U. 1907; M. A., Clark U., 1908; Ph. D., Clark U., 1911.

Instr. in Zoology, DePauw U., 1909-10; Fellow, Clark U. 1910-11; Instr in Biology, Rutgers College 1911-13; Asst. Prof. in Biology, Rutgers College, 1913-15; Assoc. Prof. of Zoology, Rutgers College, 1915-16; Prof. of Zoology, Rutgers College, 1916-18.

A. A. A. S.; Amer. Assoc. of Anatomists; American Fisheries Society; American Public Health Assoc.; Society for Experimental Biology and Medicine; Sigma Xi.

An Abnormal Human Foetus. Anatomical Record, 1908, 2, 7, p. 257-264.

Extrusion of the Winter Egg Capsule in *Planaria simplicissima*, Biol. Bull., 1908, 15, 5, p. 226-228.

Notes on the Daily Life and Food of *Cambarus bartonii bartoni*, Amer. Nat., 1908, 42 p. 710-716.

The Mating Habits of Four Species of the *Brachyura*. Biol. Bull. 1911, 21 p. 235-248.

The Biology of the Crayfish. Amer. Nat. 1912, 46, p. 279-293.

Experiments with Desiccated Thyroid, Thymus and Suprarenals. Science, 1912, 36, 932, p. 641-642.

Twins in Fish, One with a Cyclopic Deformity. Anat. Rec., 1914, 8, 6, p. 355-366.

Cyclopia in Mammals. Anat. Rec., 1914, 8, 6, p. 355-366.

An Abnormal Hens Egg. Amer. Nat., 1915, 49, p. 49-51.

Sarcophagid Larvae from the Painted Turtle. Jour. of Parasitol., 1915, 2, p. 48-49.

The Influence of Various Concentrations of Sea Water on the Viability of the Salt Marsh Mosquitoes *Aedes sollicitans* and *Aedes cantator*. Entomol. News, 1916, 27, p. 272-274.

The Influence of Salinity on the Development of Certain Species of Mosquito Larvae and its Bearing on the Problem of the Distribution of Species. Bulletin of the N. J. Ag. Exp. Sta., 1916, 299, p. 1-16.

A Biological Study of the More Important of the Fish Enemies of the Salt Marsh Mosquitoes. Bulletin of the N. J. Ag. Exp. Sta., 1916, 300, p. 1-16.

Intestinal Hernia in Two Species of Frogs. Anat. Rec., 1917, 12, 2, p. 255-258.

Hermaphroditism in *Fundulus heteroclitus*. Anat. Rec., 1917, 12 3, p. 389-396.

The Determination of Sex. The Medical Times, July, 1917.

Dytiscus as a Destroyer of Mosquito Larvae. Entomological News, December, 1917.

Mosquitoes and Man. The Medical Times, September, 1918.
Anopheles quadrimaculatus and *Anopheles punctipennis* in salt water. Science. (In press).

Studies in fish migration. I. The behavior of *Fundulus heteroclitus* on the salt marshes of New Jersey. (In press). II. The influence of salinity on the dispersal of fishes.

CLARK, FRIEND E., 649 Spruce St. 830-R.

Prof. of Chemistry. Head of Department of Chemistry, (1914).

B. S., W. V. U., 1898; Ph. D., J. H. U., 1902.

Instr. in Chemistry, W. V. U., 1902-03; Prof. of Geology, Summer School, W. V. U., 1903; Instr. in Chemistry, Penn. State College, 1903-05; Prof. of Chemistry, Centre College, 1905-14.

A. A. A. S.; The Chemical Society (London); American Chemical Society; American Electrochemical Society; The Society of Chemical Industry.

The Action of the Substituted ammonias of the Aliphatic Series on the Chlorides of Othosulphobenzoic Acid. Remsen and Clark, Amer. Chem. Jour., 1903, 30, p. 277-293.

The Polarization Capacity of Iron and Its Bearing on Passivity C. Mc. Gordon and F. E. Clark, Zeitschrift fur Elektro-chemie, 1906, 42, p. 669-772 and J. Amer. Chem. Soc., 1906, 28, p. 1535-41.

A Study of Chloro Ethers. I. The Action of Chlorodemethyl Ether on Salts of Organic Acids. F. E. Clark, S. F. Cox, and E. Mack. Jour. Amer. Chem. Soc., 1917, 39, p. 712-716.

COCHRANE, THOMAS JOSEPH, 26 Wilson Ave.

Asst. Chemist in W. Va., Agr. Exp. Sta., (1920).

B. S. Chem. Eng., New Hampshire, 1919.

CRANE, HARLEY L., 757 N. Front St. 134-R.

Assoc. Prof. of Horticulture and Asst. Horticulturist, Exp. Sta., (1914).

B. S., Agr., W. V. U., 1914; M. S. Agr., 1918.

A. A. A. S.; Amer. Assoc. of University Professors; Amer. Society For Horticultural Science.

A study of the factors governing the Efficiency of Distribution and Rate of Discharge of Spray Nozzles. W. Va. Agr. Exp. Sta., Tech. Bull., 169, 1919. pp. 65.

The Fertilization of Apple Orchards. W. Va. Agr. Exp. Sta. Bull., 1920, 174.

Factors Influencing Rate of Discharge and the distribution of spray nozzles. Proc. Amer. Soc. Hortic. Sci., 1917, p. 85-92.

Factors Influencing the length of the Profitable life of Apple trees in West Virginia. Proc. Amer. Soc. Hortic. Sci.

DADISMAN, ANDREW J., 115 Beverly Ave. 873-J.

Assoc. Prof. of Farm Economics and Asst. in Farm Management, Exp. Sta., (1916).

B. S., Agr. W. V. U. 1914; M. S., Agr., Cornell, 1914.

Amer. Economic Assoc.; Amer. Farm Economic Assoc.; Amer. Ornithologists Union.

W. Va. Agr. Exp. Sta. Bulletins as follows:

An Agricultural Survey of Brooks County. 1915, 153.

Amount and Cost of Labor Required for growing Crops in West Virginia. 1916, 163.

A Two-Year Farm Management Survey of Greenbrier and Monroe Counties. 1920, 173.

French Creek as a Rural Community. 1921, 176.

DAVIES, EARL C. H., 255 Richwood Ave. 435-J.

Assoc. Prof. of Chemistry, (1920).

A. B., Ohio Wesleyan U., 1910; M. A., Ohio Wesleyan U., 1911; Ph. D., U. of Chicago, 1917.

Instr. Ohio Wesleyan U. 1910-14; Asst. Prof., Ohio Wesleyan U., 1914-15; Instr., Washington U. St. Louis, 1917-18; Prof. and Head of Chemistry Dept., Butler College. 1918-20.

The Amer. Chemical Soc.; Sigma Xi.

The Structure of the Surfaces of Liquids, and Solubility as Related to the Work Done by the Attraction of Two Liquid Surfaces as they Approach Each Other. Jour. of Amer. Chem. Soc., 1917, 39, 3, p. 354-364.

The Orientation of Molecules in the Surfaces of Liquids. The Energy Relations at Surfaces, Solubility, Adsorption, Emulsification, Molecular Association, and the Effect of Acids and Bases on Interfacial Tension. Jour. of Amer. Chem. Soc., 1917, 39, 4.

Grinding Tips for Use in Drop Weight Apparatus for Surface Tension. Jour. of Amer. Chem. Soc. 1918, 40, 5.

DAVIS, ROLAND PARKER, 16 Demain Ave. 263-J.

Prof. and Head of Dept. of Structural and Hydraulic Engineering, (1911).

B. S., Mass. Institute of Tech., 1906; M. C. E., Cornell, 1908; Ph. D., Cornell, 1914.

Instr., Cornell, 1908-1911.

Amer. Soc. of Civil Engineers; American Railway Engineering Assoc.; Amer. Soc. for Testing Materials.

Conservation of Plane Section in Concrete Beams. Engineering Record, 1909, 60, p. 517.

- Strength of Cement Briquettes Stored in Air. *Engineering News*, 1909, 61, p. 581.
- Wood in Compression; Bearing Values for Inclined Cuts. *Engineering News*, 1912, 68, p. 953.
- Steel Highway Bridge Floors. Engineers' Society of Western Pa. 1915, 31, p. 782.
- Formulas for Design of Wedge-Shape Concrete Footings. *Engineering and Contracting*. 1918.
- Foundations of Bridges and Buildings. A joint treatise by Prof. H. S. Jacoby and R. P. Davis. McGraw-Hill Book Co., 1914.
- A Study of West Virginia Sands. Jointly with A. D. Williams and Blake Taylor. W. Va. State Road Bureau, 1914.
- Standard Specifications for Highway Bridges. W. Va. State Road Commission, 1920.
- Specifications for Highway Bridges. W. Va. State Road Bureau, 1914.
- Proper Sands for Mortar and Concrete. *Cornell Civil Engineer*, 1911, 19, p. 572.
- A Reinforced-Concrete Beam Failure. *Engineering Record*, 1911, 63, 572.
- Tests to Determine the Relationship between Density and Strength of Mortar. *Engineering-Contracting*, 1911, 35, p. 156.

DEATRICK, EUGENE PEYTON, 732 University Terrace. 29-R.

- Assoc. Prof. of Soils, Agr. Expt. Sta. (1921).
- A. B., Franklin and Marshall College, 1911; Ph. D., Graduate School, Cornell, 1917.
- Assoc. Instr. of Soils, New York State College of Agr., 1914-17; Prof. of Soils Chemistry, Penn. State Forestry School, 1917-19; Instr. of Soils, N. Y. State College of Agr., 1919-20.
- Amer. Soc. of Agronomy; Amer. Chemical Society.
- The Effect of Manganese Compounds on Soils and Plants. Cornell Memoir, 1919, 19.

DODDS, GIDEON S., 15 Brown St. 1267-R.

- Assoc. Prof. of Histology and Embryology, (1918).
- A. B., U. of Colorado, 1904; M. A., U. of Colorado, 1905; Ph. D. U. of Pennsylvania, 1910.
- Instr. in Biology, U. of Colo., 1905-08; Asst. Prof. Biology, St. Louis Univ. Med. School, 1910-11; Asst. Prof. Zoology, U. of Missouri, 1911-18.
- Amer. Soc. of Anatomists; Amer. Society of Zoologists; Ecological Society of America; A. A. A. S.; Marine Biol. Lab. Corporation, Sigma Xi.
- The Cranial Nerves of one of the Salamanders (*Plethodon glutinosus*), U. of Colo. Studies, 1906, 3, 2, p. 87-91.

- The Brain of one of the Salamanders (*Plethodon Glutinosus*)
U. of Colo. Studies, 1907, 3, 2, p. 97-108.
- Imperfectly Descended Testis. U. of Colo. Med. Bull., 1907,
3, p. 163-170.
- Scientific Expedition to Northeastern Colorado. U. of Colo.
Studies, 1907, 4, p. 145-149.
- Studies of Mesa and Foothill Vegetation; I. Geology and
Physiography of the Mesas. U. of Colo. Studies., 1908,
6, p. 11-19.
- Studies of Mesa and Foothill Vegetation; III. Distribution
of the Conifers on the Mesas. (Joint paper with W. W.
Robbins). U. of Colo. Studies, 1908, 6, p. 31-36.
- A List of the Entomostraca of Colorado. U. of Colo. Studies,
1908, 5, p. 243-250.
- Segregation of the Germ-Cells of the Teleost, *Lophius*. Jour.
Morph., 1910, 21, p. 563-611.
- Description of two New Species of Entomostraca from
Colorado, with Notes on Other Species. Proc. U. S. Natl.
Museum, 1915, 49, p. 97-102.
- A key to the Entomostraca of Colorado. U. of Colo. Studies,
1915, 11, p. 265-299.
- Altitudinal Distribution of Entomostraca in Colorado, Proc.
U. S. Natl. Museum, 1917, 54 p. 59-87.
- Entomostraca and Life Zones; a study of distribution in
the Colorado Rockies. Biol. Bull., 1920, 39, p. 89-107.

DORSEY, MAXWELL JAY, 307 University Driveway.

- Prof. of Horticulture and Horticulturist, Agr. Exp. Sta.,
(1921).
- B. S., Mich. Agr. College, 1906; M. S., Agr., Cornell, 1910;
Ph. D., Cornell, 1913.
- Instr., U. of Maine, 1906-07; Asst. Horticulturist, N. Y.
(Geneva) Sta., 1907-10; Asst. Plant Breeding, Cornell,
1910-11; Assoc. Hort., U. of Minn., 1911-21.
- A. A. A. S.; Amer. Soc. Hort. Sci., vice president, chair.
program Com.; Amer. Bot. Soc.; Amer. Genetic Assoc.;
Sigma Xi.
- The grape districts of New York and table of varieties.
N. Y. Agr. Exp. Sta. Bull., 1909, 315 p. 133-161.
- Variation in the floral structures of *Vitis*. Bull. Torrey
Bot. Club, 1912, 39, p. 37-52.
- The Inheritance and Permanence of clonal varieties. Proc.
of the Amer. Soc. for Hort. Sci., 1916, p. 1-31.
- The Duchess Apple Improved. Jour. of Heredity, 1917,
8, 12, p. 565-567.
- Hardiness in top-worked varieties of the Apple. Paper
117, Jour. Series, Minn. Agr. Exp. Sta., p. 38-45.
- Relation of Weather to Fruitfulness in the plum. Jour. of
Agr. Research, 1919, p. 103-125.

- A study of sterility in the plum. *Genetics* 4, 1919, p. 417-488.
- Some characteristics of open-pollinated seedlings of Malinda Apple. *Proc. Am. Soc. for Hort. Sci.*, 1919, p. 36-42.
- Petiole glands in the plum. *The Botanical Gazette*, 1920. 69, 5, p. 391-406.
- The Hardiness Problem. *Am. Soc. for Hort. Sci. Report* 1921.
- Some Difficulties in Fruit Breeding. *Sci. Agr.*, 1921, II, 4, p. 118-120.

EIESLAND, JOHN ARNDT, 23 Demain Ave. 317-R.

- Prof. of Mathematics, (1907).
- Ph. B., S. Dakota U., 1891; Ph. D., Johns Hopkins, 1898.
- Instr. in Math., U. S. Naval Academy, 1903-07; Prof. of Math., W. V. U., 1907.
- A. A. A. S., Amer. Math. Soc.; Amer. Math. Assoc.; Circolo Mathematico di Palermo, Italy.
- Note on a System of Differential Equations. *Amer. Jour. of Math.*, 1898.
- Thesis, published in 1899, (Lancaster, Pa.)
- On Hull—systems in space of 5 dimensions. *Amer. Jour. of Math.*, 1902.
- On a system of Differential Equations in Kinematics, 1904.
- Rational translation surfaces, 1906.
- Translation-surfaces connected with a rational quartic on the plane at infinity. 1907.
- Flat-sphere geometry. 1912, (First paper).
- Flat-sphere geometry. 1917, (Second paper).
- On the curves of a tetra-hedral complex, 1912.
- On a system of conjugate lines. *American Transac.*, 1912.
- On minimal lines and congruences in 4 dim. space. *Trans.*, 1912.
- On a contact transformation in Physics. *Bull. Amer. Trans.*, 1916.
- Flat Sphere Geometry. (Third paper), 1920.
- Flat Sphere Geometry. (Fourth paper), 1920.
- On a Plucker geometry of add. dim. space.
- On the Group of motions in an Einstein space.

FEDERER, GEORGE ANDREW, JR., 89 Washington St. 433-R.

- Asst. in Chemistry, (1921).
- A. B., W. V. U., 1920.
- American Chemical Society.

FISHER, CLAIRE, 52 University Driveway. 499-J.

- Instr. Mathematics, (1918).
- A. B., W. V. U., 1919; M. A., W. V. U., 1920.
- Phi Beta Kappa.

FORD, ORFA REX, 140 Waltman St.

Instr. Physics, (1920).

B. S., Salem College, 1915.

FORMAN, ALEXANDER HARDIE, 53 Morris St. 893-M.

Prof. Electrical Engineering, (1913).

B. S. M. E., W. V. U., 1906; E. E., W. V. U., 1908; M. M. E., Cornell, 1909; Ph. D., Cornell, 1912.

Asst. Physics, Cornell, 1909-10; Instr. Physics, Cornell 1910-13; Asst. Prof. W. V. U., 1913-16.

American Physical Soc.; Amer. Institute of Electrical Engineers; Society for Promotion of Engineering Education.

A Special Brake and Recording Mechanism for Recording the Output of a Motor. Shibley Journal, 1909, 23, 7, p. 213-220.

The Effect of Magnetization on the Opacity of Iron to Röntgen Rays. Practical Review, 1914, Series II, 4, p. 306-313.

The Effect of Magnetization on the Opacity of Iron to Röntgen Rays. Physical Review, 1914, Series II, 4, p.

FRAME, RAY IRA, 5 South Walnut Street. 1330.

Asst. in Physiology and Physiological Chemistry, (1921).

B. S., W. V. U., 1921.

GARBER, RALPH JOHN, 312 Park St.

Assoc. Prof. and Head of Dept. of Agronomy and Asst. Agronomist, Exp. Sta., (1920).

B. S., U. of Illinois, 1912; M. S., U. of Minnesota, 1917.

Asst. Prof., U. of Minnesota, 1920.

A. A. A. S.; American Society of Agronomy (member of committee on varietal standardization) Sigma Xi.

Relation of size of sample to kernel-percentage determinations in Oats. (Garber, R. J. and Arny, A. C.) Jour. Amer. Soc. of Agronomy, 1918, 10, 134-142.

A study of the Relation of some Morphological Character to lodging in Cereals. (Garber and Olsen) Jour. Amer. Soc. of Agronomy, 1919, 11, p. 173-186.

A preliminary note on the inheritance of rust resistance in oats, Jour. Amer. Soc. of Agronomy, 1921, 13, p. 41-43.

Variation and correlation in wheat with special reference to weight of seeds planted. (Garber and Arny), Jour. of Agr. Research, 1918, 14, p. 359-392.

Field Technic in determining yields of plots of grain by the rodrow method. (Garber and Arny), Jour. of Amer. Soc. of Agronomy, 1919, 11, 33-47.

Synthetic production of high protein corn in relation to breeding, (Hayes and Garber), Jour. of Amer. Soc. of Agronomy, 1919, 11, p. 309-318.

Breeding and crop plants. (Hayes and Garber), McGraw-Hill Book Co., N. Y., 1921.

Work ready for the press:

The origin of false wild oats, and, Inheritance and yield in oats with particular reference to rust reaction and panicle type.

GEORGE, ENOCH FRANKLIN, 29 Lincoln Ave. 173-R.

Asst. Prof. of Physics, (1920).

B. S., Valparaiso U., 1907; A. B., W. V. U., 1914; M. A., W. V. U., 1916; Ph. D., Ohio State U., 1920.

American Physical Soc.; Optical Society of America; Sigma Xi.

Absorption of Light by Mixtures of Inorganic Salts, Physical Review, 1921.

GIDDINGS, NAHUM JAMES, 36 University Driveway. 667-M.

Prof. and Head of Dept. Plant Pathology and Plant Pathologist, Exp. Sta., Acting Dean, College of Agr.

M. S., Vermont, 1909; Ph. D., Wisconsin, 1918.

Asst. Botanist, U. of Vermont, 1906-09.

American Phytopathological Society, (Member Executive Council and Vice-President); A. A. A. S.; Botanical Society of America, Sigma Xi.

Plant Diseases; Potato Spraying. (Jones and Giddings), Vt. Agr. Exp. Sta. Bull. 1909, 142.

Bacterial Soft Rot of Muskmelon, caused by *Bacillus Melonis* n. sp. Vt. Agr. Exp. Sta. Bull. 1910, 148.

Potato Spraying in 1909-1910. W. Va. Agr. Exp. Sta. Rep. 1910, p. 18-22.

Diseases of Garden Crops and their control. W. Va. Agr. Exp. Sta. Bull., 1909, 123.

Experiments in The Production of Sanitary Milk. (Atwood, Horace and Giddings), W. Va. Agr. Exp. Sta. Bull., 1911, 134.

Potato Spraying Experiments in 1911. W. Va. Agr. Exp. Sta. Rep. 1912, p. 77-79.

Investigations of the Potato Fungus, *Phytophthora infestans*, (Jones, Giddings and Lutman) U. S. D. A. Bur. Plant Ind. Bull. 1912, 245.

A Practical and Reliable Apparatus for culture Work at Low Temperatures. Phytopathology, 1912, 2, p. 106-109.

The Chestnut Bark Disease. W. Va. Agr. Exp. Sta. Bull. 1912, 137.

Control of Apple Rust by Spraying. (Giddings and Neal), Phytopathology, 1912, 2, p. 258.

Orchard Spraying. (Alderman, Giddings and Rumsey), W. Va. Agr. Exp. Sta. Circ. 1913, 7.

The Collar Blight of Apple Trees, W. Va. Dept. Agr. Rep. 1913, 29, p. 15-18.

- The Effect of Pressure on certain Microorganisms Encountered in the Preservation of Fruits and Vegetables. (Hite, Giddings and Weakley) W. Va. Agr. Exp. Sta. Bull. 1914, 146.
- Apple Rust. (Giddings, Berg, and Anthony), W. Va. Agr. Exp. Sta. Bull. 1915, 154.
- Apple Rust or Cedar Rust in West Virginia. (Giddings, Berg and Anthony), W. Va. Agr. Exp. Sta. Circ 1915, 15.
- New or Noteworthy Facts Concerning Apple Rust. (Giddings, Anthony and Berg), Phytopathology 1016, 6, p. 79.
- Potato and Tomato Diseases. W. Va. Agr. Exp. Sta. Bull. 1917, 165.
- Orchard Spraying Versus Dusting. W. Va. Agr. Exp. Sta. Bull. 1918, 167.
- Infection and Immunity in Apple Rust. W. Va. Agr. Exp. Sta. Bull. 1918, 170.
- A Comparison of the Late Blights of Tomato and Potato. (Giddings, Anthony and Berg), Phytopathology 1016, p. 209-211.
- Orchard Dusting vs. Spraying. Jour. Econ. Entom. 1921, 14, p. 225-231.

GILL, JAMES HERBERT, 728 N. Front St. 831-R.

Prof. Machine Construction and Superintendent of Shops, (1920).

B. M. E., U. of Minn., 1892; M. E., U. of Minn., 1894.

Instr. Metal Working, U. of Minn.; Asst. Prof. Mach. Eng., Mont. A. and M. College; Asst. Prof. of M. E. Mach. Constr., U. of Ill.

Bulletins for Federal Board for Vocational Education.

GROW, GEORGE WALTER, 86 Green St.

Asst. Prof. Drawing and Machine Design, (1912).

B. S. M. E., W. V. U., 1912; M. S. Eng., Mass. Inst. of Tech., 1916.

GRUMBEIN, JOHN B., 260 McLane Ave. 881-J.

Prof Steam and Experimental Engineering, (1903).

B. S. M. E., W. V. U., 1909; M. M. E., Cornell, 1914.

Amer. Soc. for Testing Materials; Amer. Soc. for the Promotion of Engineering Education, Amer. Soc. of Mechanical Engineers.

HALL, ARTHUR A., 506 Forest Ave. 175-M.

Assoc. Prof. of Electrical Engineering, (1916).

B. S. M. E., W. V. U. 1906.

A. A. A. S.

- HALL, GOLDEN O.**, 293 Willey St. 205-R.
Asst. Poultry Husbandry, (1921).
B. S., Agr., W. V. U., 1921.
Amer. Assoc. of Instructors and Investigators in Poultry Husbandry.
- HAMMOND, ELMER L.**, 301 Park St. 283-R.
Instr. Pharmacy, (1921).
Ph. C., U. of Mich., 1921; B. S., Pharmacy, U. of Mich., 1921.
Asst. in Pharmacy, U. of Mich., 1919-21.
- HARDY, IRVIN, S.** Walnut St. 629-J.
Clinical Prof. of Surgery, (1913).
A. B., Milton Academy; M. D., Maryland Med. College, 1899;
M. D., Queens U., Ont., 1909.
A. A. A. S.; Amer. Med. Assoc.; American College Surgeons.
- HAYES, LESLIE DAVID**, 728 University Terrace. 831-R.
Prof. Machine Design and Construction, (1918).
B. S. New Hampshire, 1897; M. E., Cornell, 1908.
Instr., in Mach. Design, Cornell, 1907-10; Asst. Prof. of Machine Design, Cornell, 1910-18.
American Society of Mechanical Engineers.
The Nature of Rolling and Sliding Between Bodies in Direct Contact. Sibley Jour. of Eng., 1916.
The Design and Use of Twisted Spur Gears, Amer. Machinist, 1917.
- HAYMAN, J. LESTER**, 258 First St.
Instr. Pharmacy. (1919)
Ph. G., U. of Mich., 1919; B. S., U. of Mich., 1919.
Asst. in Chemistry, U. of Mich., 1918.
- HICKMAN, CLEVELAND P.**, 425 N. Willey St. 329-R.
Instr. in Zoology, (1921).
A. B., Salem College, 1917; M. A., U. of Mich., 1920.
Graduate Asst. in Zoology, U. of Mich., 1920-21.
Sigma Xi.
- HILL, HUBERT**, 186 First St. 474-R.
Assoc. Prof. Chemistry. (1913).
B. S., U. of N. Carolina, 1907; M. S., U. of N. Carolina, 1908.
Instr., N. Carolina A. and M. College, 1908-10; Instr., W. V. U., 1913-16; Asst. Prof., W. V. U., 1916-20; Assoc. Prof., W. V. U., since 1920.
Amer. Chemical Soc.; Amer. Assoc. of Univ. Prof.
- HODGE, WILLARD W.**, 293 Willey St. 205-R.
Prof. Chemical Engineering, (1921).

A. B., Ripon College, 1909; M. A., U. of Wis., 1912; M. A., Yale, 1913.

Grad. Asst., Yale, 1912-13; Prof. Chem. and Physics, Albany College 1915-17; Instr. Chemistry, U. of N. Dakota, 1917-18; Asst. Prof. Organic and Physical Chem., Oregon State Agr. College, 1918-21.

American Chemical Society.

Desulfurization of 2-Thiohydantoins. Jour. Amer. Chem. Soc., (Johnson, Pfau and Hodge), 34, 8.

A New Method of synthesizing the Higher Phenols. Jour. Amer. Chem. Soc., (Johnson and Hodge), 35, 8.

HODGSON, JOSEPH ELLIS, 209 Grant Ave. 254-R.

Prof. Mathematics, (1912).

A. B., Wash. and Lee, 1898; Ph. D., Johns Hopkins, 1910.

Instr. in Math., Davis and Elkins, 1904-06; Instr. in Math., Baltimore Polytech Inst., 1908-12; Assoc. Prof. in Math., W. V. U., 1912-13; Prof. in Math., W. V. U., since 1913.

Amer. Mathematical Soc.; Amer. Mathematical Assoc.; Amer. Assoc. of Univ. Prof.

Orthocentric Properties of the Plane Directed N-Line. Transac. of Amer. Math. Soc., 1912.

JACOBSON, CARL ALFRED, 219 Cedar St. 787-M.

Professor of Chemistry (1920).

B. S., Carleton College, 1903; M. S., Carleton College, 1907; Ph. D., Johns Hopkins, 1908.

Research chemist, Rockefeller Institute for Medical Research, 1908-09; Prof. of Chemistry, U. of Nevada, and Chief Chemist of the Nevada Agr. Exp. Sta., 1909-1918.

Amer. Chemical Soc.; Amer. Bio-chemical Soc.; A. A. A. S.; Nat. Geographic Soc.

The conductivity and ionization of electrolytes, as conditioned by temperature dilution and hydrolysis. Am. Chemical Jour., 1908.

Ueber Carnaubon; ein glycerinfreies phosphatid, lecithin ähnlich konstituiert mit galaktose als kern. Zeit. f. physiol. chem., 64, p. 302.

Myristone, obtained from alfalfa. Jour. Am. Chemical Soc., 33, p. 2048.

An improved extractor. Jour. Am. Chemical Soc., 33, p. 2052.

Alfalfone, a ketone of the formula $C_{21}H_{42}O$. Jour. Am. Chem. Soc., 34, p. 300.

On the duality of chlorophyll, and the variable ratio of the two constituents. Am. Chem. Jour., 47, p. 221.

Methods for determining Neo—and Allochlorophyll in the presence of one another. Am. Chem. Jour., 48, p. 111.

On the coloring matters in alfalfa. Jour. Am. Chem. Soc., 34, p. 1263.

- A delicate method for determining minute quantities of chlorophyll. Jour. Am. Chem. Soc., 34, p. 1266.
- Water hemlock: A technical bulletin, Nev. Agr. Exp. Sta., 1915, 81.
- Enzymes present in alfalfa seeds. Jour. Am. Chem. Soc., 34, p. 1730.
- Enzymes present in alfalfa. Jour. Am. Chem. Soc. 36, p. 2170.
- Cicutoxin. Jour. Am. Chem. Soc., 37, p. 916.
- The need of a large Government institution for chemical research. Jour. of Industrial and Engineering Chem. 8, p. 70.
- Some aspects of scientific research. Science, N. S., 44, p. 598.
- Alfalfa seed oil. Jour. Am. Chem. Soc. 38, p. 480.
- Solubility data for various salts of lauric, myristic, palmitic, and stearic acids. Jour. of Biological Chem. 25, p. 29.
- The separation of lauric and myristic acids from each other and from mixtures of other fatty acids. Jour. of Biological Chem. 25, p. 55.
- The importance of scientific research to the industries. Science, N. S. 44, p. 456.
- Alfalfa saponin.—alfalfa investigation VII. Jour. Am. Chem. Soc. 41, p. 640.
- A universal calculating machine for chemical calculations. Chemical Age. 30, p. 51.
- JAMISON, ROBERT R.**, 248 Jackson Ave. 1199-J.
Instr. Horticulture (1921).
B. S., Agr., Purdue U., 1919.
- JOHNSON, MARY MARTIN**, Woman's Hall. 9775.
Asst. in Chemistry (1921).
A. B., Meredith College, 1921.
- JONES, CLEMENT ROSS**, 317 Willey Street. 205-J.
Dean College of Engineering (1895).
B. S. C. E., W. V. U., 1894; M. E., W. V. U., 1897; M. M. E., Cornell, 1900
Asst. in Mechanical Engineering, 1895-97; Instr. in Mechanical Engineering, 1897-99; Asst. Prof. in Mechanical Engineering, 1899-1901; Prof. in Mechanical Engineering, 1901-11.
A. S. M. E.; S. P. E. E.; A. A. A. S.; Am. S. T. M.; Sigma Xi; Land Grant College Assoc.
Specific Heat of Superheated Steam. A thesis for the degree of M. M. E., Cornell.
Power losses in Belt Transmission. Power Losses in Transmitting Through a Countershaft. Amer. Soc. Mech. Engr., 1894, 15, p. 725-729.

- Elective Studies in Engineering Courses. Soc. for the Promotion of Engineering Education, Proceedings . 1899, 7, p. 130-137.
- Test of Arndt's Gas Weighing Econometer. Sibley Jour. 1900, 4, p. 355-366.
- The Distribution of Power in Shops and Factories From Central Stations. Transac. of the Appalachian Eng. Assoc., 1908, 19.
- A study of the Elastic Properties of a Series of Iron-Carbon Alloys.
(With C. W. Waggoner) Amer. Soc., for Testing Materials. 1911, 11.
- Mining Extension in West Virginia. Proc. of Land Grant College Engineering Assoc. 1914.
- What the Land Grant Colleges Can do to Aid the State Governments.
Proc. of the Land Grant College Eng. Assoc., 1913.
- The Page and Lever Bills. Proc. of the Land Grant College Eng. Assoc., 1913.
- Scientific Management as Applied to Farm, Home and Manufacturing Plant. Proc. of 30th Convention of the Assoc. of Amer. Agr. Colleges and Exp. Sta.
- The Relation of the University to the Natural Gas Industry. W. Va., Natural Gas Assoc. 1917.
- Labor Saving Machinery. W. Va., Coal Mining Institute, 1919.
- KAPLAN, BENJAMIN B.**, 247 Richwood Ave. 186-R.
Chemist Geological Survey, (1920).
B. A., Harvard, 1918.
Jr. Chemist, U. S. Bureau of Mines, Pittsburgh, 1918-20.
Amer. Chemical Society.
Hygroscopicity of by-products coke. Jour. of Industrial and Engineering Chemistry 1920, 12, p. 783.
- KERSLAKE, CHARLES D.**, 204 Simpson St. 678-J.
Instr. Mechanics (1921).
C. E. Rensselaer Polytechnic Institute, 1917.
Instr. Rensselaer Polytechnic Inst. 1919-21.
- KESSEL, CHARLES ROYALL**, 85 South High St. 1295.
Assoc. Prof. Pharmacology (1921).
B. S., W. V. U., 1919; M. D., Jefferson, 1921.
- KNIGHT, HENRY G.**, 118 Park St. 1370.
Director and Research Chemist, Agri. Exp. Sta., College of Agr. (1922).
B. A., U. of Washington, 1902; M. A., U. of Washington, 1904;
Ph. D., U. of Illinois, 1917.
Asst. in Chemistry, U. of Washington, 1900-01; Instr. of

- Chem., U. of Wash., 1901-02; Asst. U. of Chicago, 1902-03; Asst. Prof. of Chemistry, U. of Wash. 1903-04; Prof. of Chem. and State Chemist, U. of Wyo., 1904-10; Director, Exp. Sta., 1910-18, Dean of Agr., 1911-18, Dean of Agr. and Director of the Exp. Sta. Okla. Agr. Col., 1918-21.
- Assoc. of Land Grant Colleges, Amer. Chemical Society, National Geographic Soc.
- Some Food Products and their Adulteration. Wyoming Sta. Bull., 1904, 62.
- Wyoming Forage Plants and their Chemical Composition. Wyoming Sta. Bull., 1905, 65.
- Digestion Experiments with Wethers. Wyo. Sta. Bull., 1906, 69.
- Wyoming Forage Plants and their Chemical Composition. Wyo. Sta. Bull., 1906, 70.
- Wyoming Forage Plants and their Chemical Composition. Wyo. Sta. Bull., 1908, 76.
- Digestion Experiments II. Wyo. Sta. Bull., 1908, 78.
- Soil Nitrogen. Wyo. Sta. Bull., 1909, 82.
- Wyoming Forage Plants and their Chemical Composition-IV. Wyo. Sta. Bull., 1911, 86.
- The Chemical Examination of Death Camas. Wyo. Sta. Bull., 1912, 94.
- The Identification of Woody Aster. Wyo. Sta. Bull., 1913, 97.
- Meteorology for Twenty years. Wyo. Sta. Bull., 1913, 100
- Alkali VI. Seventeenth Annual Report Wyo. Exp. Sta., 1906, p. 45.
- Two Important Western Poisonous Plants. Rep. Soc. Pro. Agr. Sc. 1912.
- Notes on Qualitative Analysis, Byers and Knight, D. Van Nostrand, 1912.
- Acidity and Acidimetry of Soils. Studies of the Hopkins and Pettit Method for determining soil acidity. Jour. Ind. and Eng. Chem. 1920, 12, p. 340.
- Acidity and Acidimetry of Soils-II-Investigation of Soils by Means of the Hydrogen Electrode. Jour. Ind. and Eng. Chem. 1920, 12, p. 457.
- Acidity and Acidimetry of Soils-III-Comparison of Methods for Determining Lime Requirements of Soil with the Hydrogen Electrode.
- IV. Proposed Method for the Determination of Lime Requirements of Soils. Jour. Ind. and Eng. Chem., 1920, 12, p. 559.

KNOWLTON, HARRY EDWARD, 628 Spruce Street. 71-M.

Assoc. Prof. Horticulture and Assoc. Horticulturist, Exp. Sta. (1919).

B. S., Michigan Agr. College, 1912; Ph. D., Cornell, 1920.

- Instr. Plant Physiology, Cornell, 1916-19.
Sigma Xi.
Methods in Apple Pollination Experiments, Proc. Soc. Hort. Sci. 1920, p. 44-47.
A preliminary Experiment in half-tree fertilization. Proc. Soc. Hort. Sci. 1921.
Studies in pollen with special reference to longevity. Cornell Memoir. 1922, 52, p. 751-793.
- KUNST, FRANK B., Hough St. 1028.
Chemist Exp. Sta. (1901).
B. A., W. V. U., 1906.
- LAWALL, CHARLES E., 665 Spruce St. 251-M.
Instr. in Mining. (1921).
Eng. of Mines, Lehigh U., 1914; M. S., Lehigh U., 1921.
Instr. in Geology, Lehigh U., 1920-21.
- LAZZELL, CHARLES L., 257 McLane Ave. 717-M.
Instr. Chemistry. (1921).
B. A., W. V. U., 1918; M. S., W. V. U., 1921.
Graduate Asst. Chemistry, W. V. U., 1919-21.
American Chemical Society.
- LEITH, T. B., 749 N. Front St.
Asst. Chemist, W. V. U. Agr. Exp. Sta. (1919).
B. A., Washington and Lee, 1916.
Asst. in Biology, Wash. and Lee, 1912-13; Asst. Chemist, Texas Exp. Sta., 1917-18; Asst. Prof. of Physiological Chemistry, Maryland State College, 1918-19; Asst. Chemist, W. Va., Agr. Exp. Sta., since 1919.
- LIVESAY, EDWARD A., 234 Prospect St. 731-R.
Prof. Animal Husbandry. (1919).
B. S., Virginia Polytechnic Inst., 1912; M. S., Virginia Poly. Inst. 1916; A. M., U. of Missouri, 1917.
Instr. Virginia Poly. Inst., 1914-16; Asst. Co. Agt. Leader, U. of Missouri, 1917-19.
American Society of Animal Production.
- LONGWELL, JOHN H., 29 Lincoln Ave. 974-M.
Asst. Prof. Animal Husbandry, (1921).
B. S., Agr., U. of Missouri, 1918; M. S., Agr., U. of Missouri, 1920.
Research Asst., U. of Missouri, 1919-20; Instr., An. Husb., Wash. State College, 1920-21; Asst. Prof., An. Husb., W. V. U., 1921.
- LUEDER, CHARLES AUGUSTUS, 752 N. Front St. 804-R.
Prof. Veterinary Science (1908).
D. V. M., New York State Veterinary College, 1902.
American Veterinary Medical Assoc.

MOLBY, F. A., 506 High St. 796-R.

Prof. of Physics (1920).

A. B., Baker U., 1904; M. A., Cornell U., 1908; Ph. D., Cornell, 1910.

Instr. in Physics, Cornell U., 1908-12; Asst. Prof. of Physics Indiana U., 1912-18; Asst. Prof. of Physics, U. of Cincinnati, 1918-20.

American Physical Society.

Rotatory Powers of optically active substances at Low Temperatures, Physical Review, 1908, 10.

Refractive Indices at Low Temperatures. Physical Review, 1911.

MONTGOMERY, A. G., 9 South High St. 1368-R.

Instr. Mathematics (1919).

B. A., W. V. U., 1917; M. A., W. V. U., 1921.

MORRIS, RUSSELL L., 294 Grand St. 621-J.

Prof. Railway and Highway Eng. (1895).

C. E., W. V. U., 1898.

MORRIS, SAMUEL, 56 University Driveway. 1251-R.

Prof. Chemistry (1916).

Ph. D., Ohio State U., 1921.

Asst. Prof. of Chemistry, State College of Washington, 1909-12; Instr in Chemistry, College of Wooster, 1912-16.

American Chemical Society: Sigma Xi.

The Comparative Value of Different Specimens of Iodine for use in Chemical Measurements. (With C. W. Foulk). Jour. of the Amer. Chemical Society. 44, 2, p. 221.

MORRIS, SAMUEL J., 83 Kingwood St. 696-J.

Prof. Anatomy (1912)

M. D., College of Physicians and Surgeons, Baltimore, 1912;

Asst. Prof. of Anatomy, W. V. U., 1912-16; Assoc. Prof. of Anatomy W. V. U., 1917-20; Prof. of Anatomy, W. V. U., since 1920.

American Med. Assoc.; Assoc. for Study of Internal Secretions.

Relation of the Persistent Thymus Gland to Criminology. Medical Record, 1921.

The Thymus Gland. W. Va., Medical Journal, 1921.

Working on effect of drugs on gall bladder; Autointoxication and Insanity.

MORSE, WITHROW, 211 Gordon St. 13-J.

Prof. Physiological Chemistry (1918).

B. S., Ohio State, 1903; M. A. Ohio State, 1904; Ph. D., Columbia, 1909.

- Instr. Physiological chemistry, Cornell, 1906-12; Research Instr. U. of Wisconsin, 1913-14; Prof. of Physiological Chem. U. of Nebraska; Chemist, Nelson Morris Research Inst., 1916-18.
- Amer. Chemical Society; Biochemical Assoc. (Vice Pres., 1911).
- American Society of Biological Chemists; Biochemical Society (London); Sigma XI.
- The Nuclear Components. *Archiv Fur Zellforschung* (Leipzig) 3, p. 483.
- Retention of Normal Polarity in centrifuged stems of tubularia. *Proc. Soc. Exp. Biol. and Med.*, 8, p. 29.
- Artificial Parthenogenesis and Hybridization. *Jour. Exp. Zoology* 1912, 13 p. 471.
- The Role of Phagocytosis in involuting organs. *Proc. Soc. Exp. Biol. and Med.*, 1912, 10 p. 31.
- Inorganic Colloids and protoplasm. *Science*, 1913, 37, p. 423.
- On the comparative physiology of creatin and creatinin. *Biochem. Bull.*, 1913, 2, p. 546.
- A Mikro-Kjeldahl apparatus. *Biochem. Bull.*, 1913, 2, p. 457.
- The effective principal in thyroid. *Jour. Biol. Chem.*, 1914, 19, p. 421.
- Autolysis and involution. *Amer. Jour. Physiol.*, 1914, 36, p. 145.
- Studies of autolysis. I. The accelerating effect of Manganous Chloride on Liver autolysis. *Jour. Biol. Chem.* 21, p. 209.
- Autolysis and Nuclear Relations. *Biochem Bull.*, 1915, 4, p. 226.
- Non-toxicity of inorganic colloids upon protozoa. *Biochem. Bull.*, 1915, 2, p. 161.
- Is autolysis an autocatalytic phenomenon? *Jour. Biol. Chem.*, 1916, 24, p. 163.
- Hydrogen ion concentration in autolysis. *Jour. Biol. Chem.*, 1916, 24, p. 27.
- Creatin in poliomyelitis. *Jour. Biol. Chem.*, 1916, 24, 28.
- Nitrogen retention in nephritis in children. *Proc. Soc. Exp. Biol. and Med.*, 1916, 13, p. 92.
- Studies in the metabolism of children. I. The excretion of creatinin and creatin in acute nephritis. (With Cutter, I. S.) *American Jour. Diseases of Children*, 1916, 2, p. 326.
- Oxygen relations in autolysis. *Biochem. Bull.* 1916, 5, p. 143.
- Enzyme and substrate in autolysis. *Jour. Biol. Chem.*, 1916, 30, p. 197.

- Enzyme and reaction of medium in autolysis. Jour. of Biol. Chem. 1916, 31, p. 303.
- The role of autoysis in infarction. Proc. Soc. Exp. Biol. and Med., 1917, 14, p. 171.
- The role of the liver in hippuric acid synthesis. (With Levinson) Biochemical Bulletin (London) 1917, 12, p. 184.
- The role of halogens as acclerators of tissue enzyme action. Jour. Biol. Chem., 1917, 22, p. 125.
- Factors involved in atrophy. Biol. Bulletin, 1918, 34, p. 149.
- The effect of compression on tissue enzymes. Pro. Soc. Exp. Biol. and Med., 1920, 17, p. 132.
- Is glycogen the source of acids developed in autolysis? Proc. Soc. Exp. Biol. and Med., 1921, 18, p. 246.
- The change of reaction in dying tissue. (With Van Der Heyde, H. C.) Proc. Soc. Exp. Biol. and Med., 1921, 19, p. 27.
- Further studies in the reaction of dying tissue. (With Goldberg R.) Jour. Biol. Chem., 1922, 50, p. 38.
- NORCROSS, ARCHER R.**, 305 University Driveway. 1022-R.
Instructor Structural and Hydraulic Engineering (19221).
B. S. C. E., U. of California, 1919.
- NELSON, ROY E.**, 15 Brockway Ave.
Instr. of Surveying (1921).
B. S. C. E., W. V. U., 1921.
- ODLAND, THEODORE E.**, 39 Maple Ave. 681-W.
Asst. Prof. Agronomy. (1921).
B. S., U. of Minnesota, 1917; M. S., U. of Minnesota, 1920.
Instr., U. of Minn., 1919-20; Asst. Prof., U. of Minn., 1920-21.
American Society of Agronomy; A. A. A. S.
- PEAIRS, LEONARD M.**, 50 Jones Ave. 895-R.
Prof. Entomology and Entomologist Exp. Sta. (1912).
B. S., Kansas State Agr. College, 1905; M. S., Kansas State College, 1907.
Asst. Ent. and Zool., Kansas Agr. College, 1905-07; Asst. to State Entom., Illinois, 1907-08; Instr. in Ent. and Zool., Maryland State College, 1908-09; Asst. Prof. in Ent. and Zool., Maryland State College, 1909-10; Instr. in Ent. and Zool., Kansas Agr. College, 1910-12 Assoc. Prof. Entomology, W. V. U. 1912-14; Prof. Entomology, W. V. U., 1914; Entomologist, W. V. U. Agr. Exp. Station, 1912.
Amer. Assoc. of Economic Entomologists; Amer. Entomological Soc.; Entomological Society of France; A. A. A. S.; Entomological Soc. of London; Sigma Xi.
Insects and Insect Control. Bulletins from Exp. Sta. of Maryland, Kansas, W. Va., and New Hampshire.

School Entomology. (With Sanderson) John Wiley and Sons, 1917.

Insect Pests. (With Sanderson) John Wiley and Sons, 1921

Volume on Insects in an Agriculture Encyclopedia to be published by the Bellow-Reeves Co., 1922.

QUISENBERRY, KARL S., 48 University Driveway. 563-R.

Instr. in Agronomy (1921).

B. S., Agr., Kansas State College, 1921.

Nursery Foreman, Kansas Exp. Sta., 1918-21.

American Soc. of Agronomy, American Genetic Assoc.; A. A. A. S.

RAINES, MORRIS A., 56 University Driveway. 1251-R.

Instr. in Botany, (1920).

B. S., Columbia College, 1915; M. A., Columbia U., 1917; Ph. D., Columbia U., 1921.

Instr., N. Y. U., 1916; Research Asst. Columbia U., 1916-17; Gottsberger Fellow, Columbia U., 1919-20.

A. A. A. S.; Botanical Society of America; Sigma Xi.

Rotary Vertigo in the Tail-spin. Science, N. S., 1919, 49, 266-267.

Vegetative Vigor of the Host as a Factor Influencing Susceptibility and Resistance to Certain Rust Diseases of Higher Plants. Amer. Jour. of Botany, 1922, 9, p. 183-203 and 215-238.

REESE, ALBERT MOORE, 312 Park St. 683-W.

Prof. of Zoology (1907)

B. A., Johns Hopkins U., 1892, Ph. D., Johns Hopkins U., 1900.

Lecturer in Embryology, Pennsylvania College, 1896; Prof. of Biology and Geology, Allegheny College, 1901-02; Instr. and Assoc. Prof., Syracuse U., 1902-07.

A. A. A. S., member of council, member of sectional committee; American Soc. of Zoologists; American Society of Herpetologists. American Microscopical Society.

Introduction to Vertebrate Embryology, 2nd ed., G. P. Putman's Sons, 1909, 21, p. 340.

The Alligator and Its Allies. G. P. Putman's Sons, 1915, p. 316.

Wanderings in the Orient. Open Court Pub. Co., (In press).

Embryology of the Florida Alligator. Proc. International Zool. Congress. 1907, p. 1-3.

Development of the American Alligator. Smith. Misc. Coll. 1908, 1791, p. 1-66.

An Abnormality in the Circulation of the cat. Anatomischer Anzeiger. 1909, 35, p. 365-66.

Variations in the Tentacles of Hydra Viridis. Science. 1909, 29, p. 433-34.

- Development of the Brain of the American Alligator. Smithsonian Misc. Coll. 1910, 1946, p. 1-25.
- The Lateral line System of *Chimaera Colliei*. Jour. Exp. Zool., 1910, p. 349-70.
- Food and Chemical Reactions of the Spotted Newt, *Diemystylus viridescens*. Jour. Animal Behavior. 1912, p. 190-209.
- The Effect of Narcotics upon the Development of the Hen's Egg. Science, 1912, p. 633-34.
- A Convenient Microscope Case. Amer. Naturalist. 1913, p. 121-122.
- The Osteology of a Double-Headed Calf. Amer. Nat., 1914, p. 701-04.
- The Histology of the Enteron of the Florida Alligator. Anatomical Record, 1913, p. 105-29.
- The Vascular System of the Florida Alligator. Proc. Acad. Nat. Sci. Phila., 1914, p. 413-25.
- The Development of the Lungs of the Alligator. Smithsonian Misc. Coll., 1915, 2356, p. 1-11.
- Variations in the Vermillion Spotted Newt. Amer. Nat., 1916, p. 316-19.
- Light Reactions of the Crimson Spotted Newt. Jour. Animal Behavior, 1917, p. 29-48.
- The Blood of Alligator Mississippiensis. Anat. Rec. 1917, p. 37-44.
- The Anatomy of a Two-Headed Lamb. Anat. Rec., 1917, p. 179-97.
- Caïman hunting in South America. Natural History, 1920-20, p. 444-47.
- Structure and development of integumental glands in the Crocodilia. Jour. of Morphology, 1921, 35, p. 581-610.
- Venomous spiders. Science, 1921, 54 p. 382-85.
- Unusual animal foods. Scientific Monthly, (In press).
- Habits of the Tegu lizard, *Copela*. (In press).

- REYNOLDS, CLARENCE NEWTON, Jr., 223 Demain Ave. 317-R.
Asst. Prof. of Mathematics (1921).
Ph. B., Brown University, 1913; M. A., Brown U., 1914; Ph. D., Harvard, 1919.
Instr. in Math., Wesleyan U., Conn., 1916-20; Instr. in Math., Dartmouth College, 1920-21.
American Mathematical Society; Mathematical Assoc. of America.
Linear Differential Equations of the fourth order whose solutions satisfy a homogeneous quadratic identity. Bulletin of the Amer. Math. Soc., 1920, 2nd Series, Vol. 26, p. 277.

The zeros of Solutions of Homogeneous Linear Differential Equations. Transac. of the Amer. Math. Society. 1921, 22, p. 220.

ROPP, CLARENCE D. L., 250 First St. 1083-R.

Senior Graduate Asst. Chemistry (1921).

B. A., W. V. U., 1921.

DuPont Scholarship in Chemistry, W. V. U., 1920-21.

Phi Beta Kappa.

ROUSH, EVA M. FLING, 145 Beverly Ave. 614-J.

Instr. of Botany (1919).

B. A., W. V. U., 1911; M. A., W. V. U., 1920.

Asst. in Botany, W. V. U., 1917-19.

RUMSEY, WILLIAM E., 415 Park St. 671-R.

State Entomologist, Exp. Sta. (1893)

B. S., Agr., Cornell U., 1891.

Amer. Assoc. of Economic Entomologists and Entomological Soc.; American Assoc. of Official Horticultural Inspectors.

Second vice-pres. of A. A. E. E.; Chairman of A. A. O. H. I. Manner of Birth of the Woolly Aphis of the Apple (*Schizoneura lanigera* Hausm) and of other Aphididae. Proc. of the 19th Annual Meeting of the Assoc. of Economic Ent., Bulletin 67 of the U. S. Bureau of Entomology, p. 31-33.

Spraying for San Jose Scale. (Rumsey and F. E. Brooks). Spe. Bull., 4, W. Va., Agr. Exp. Sta., 1907, p. 1-8.

Enemies of Young Fruit Trees. (Rumsey and F. E. Brooks). Bull. W. Va., Agr. Exp., 1908, 116, p. 230-243.

Spraying for the Codling Moth. Bull. W. Va., Agr. Exp. Sta., 1910, 127, p. 127-141.

Cabbage worms and suggestions for destroying them. (Rumsey and Brooks). Bull., W. Va., Agr. Exp. Sta. 1909, 120, p. 345-352.

Suggestions for spraying. Bull. W. Va., Agr. Exp. Sta. 1911, 133, p. 57-78.

Some Orchard Insects. Circ. W. Va., Agr. Exp. Sta. 1913, 7, p. 24-37.

The San Jose Scale. Bull. W. Va., Crop Pest Com. 1914, 3, p. 1-16.

The Periodical Cicada in West Virginia in 1914. Bull. W. Va., Crop Pest Com. 1914, 4, p. 1-10.

Some Common Insects and Plant Diseases of the Farm, Garden and orchard. Bulletin W. Va., Dept. of Agr. 1916, 17, p. 1-38.

The Periodical Cicada or So-called 17 year Locust in West Virginia in 1919. Bulletin W. Va., Department of Agr. 1918, 37, p. 1-8.

- SCHEFFEL, EARL READ**, 640 N. High St. 796-J.
Asst. Prof. Geology (1919).
B. S., Denison University, 1907; M. S., Denison U., 1908;
Graduate work U. of Ill., and U. of Chicago.
Instr. Geology and Mineralogy, Lawrence College, 1908-11;
Asst. U. of Illinois, 1911-12.
A. A. A. S.; National Geographic Society.
An Esker Group South of Dayton, Ohio. *The Ohio Naturalist*. 1908, 8. Also in *Bulletin of the Sci. Lab. of Denison University*. 1908, 14, p. 19-33.
The origin of Spring Valley Gorge. *Bull. Sc. Lab. Den. Uni.*, 1906, 13, p. 154-166.
Significance of Drainage Changes near Granville, Ohio, *Bull. of the Scientific Lab. of Den. Univ.* 1909, p. 157-174.
Slides in the Conemaugh Formation near Morgantown, West Virginia.
The Jour. of Geology. 1920, 28, p. 340-355.
- SCOTT, PARRY M.**, 299 Price St. 333-R.
Asst. in Pathology and Bacteriology (1921).
B. S., W. V. U., 1921.
- SEFTON, LILY B.**, 371 Front St.
Asst. Prof. Chemistry. (1920).
B. S., Denison U., 1911; M. S., Ohio State U., 1917; Ph. D., Ohio State U., 1921.
Instr. Denison U., 1911-17; Asst. Prof. and acting head of Dept. of Chemistry, Denison U., 1916-18.
American Chemical Soc., Sigma Xi.
- SHAW, EDWARD L.**, N. Front St.
Sheep Specialist, Agr. Exp. Sta. (1917).
B. S., Agr., Ohio State U., 1902.
- SHERWOOD, EVERETT C.**, 79 Grant Ave. 368-R.
Specialist in Plant Pathology, Agr. Extension Staff. (1920)
B. S., Agr. Oklahoma A. and M. College, 1918; M. S., U. of Wisconsin, 1920.
Sigma Xi.
- SHIREY, WILLIAM B.**, 41 Jones Ave. 754-M.
Graduate Asst. Chemistry (1921).
B. A., W. V. U., 1921.
American Chemical Soc.
- SIMPSON, JOHN N.**, 14 Willey Driveway. 244-J.
Dean and Professor of Medicine (1902).
B. A., U. of Nashville, 1893; M. D., Johns Hopkins U., 1902.
American Medical Assoc.; American College of Physicians;
American Academy of Medicine.

- SMITHEY, IRA W.**, 550 Spruce St. 284-W.
Instr. Chemistry. (1921).
B. S., U. of N. Carolina, 1918; M. S., U. of N. Carolina, 1920;
Ph. D., U. of N. Carolina. 1921.
Instr. in Chem., U. of N. Carolina, 1918-21.
Amer. Chem Society; N. Carolina Acad. of Science; Sigma
Xi.
Zirconyl compounds with the Oxy-halogen acids. Jour.
Amer. Chem. Soc., 1919, 41, 2.
Doctors Thesis to be published—Bromine derivatives of a
di-amino-p-cymene nucleus.
- SPANGLER, ROBERT C.**, 13 Naomi St. 207-J.
Asst. Prof. Botany (1914).
B. A., W. V. U., 1914; M. A., W. V. U., 1916.
Instr. of Botany, W. V. U., 1914-20; Asst Prof. of Botany
since 1920.
- SPRAY, ROBERT SPALDING**, 149½ Beverly Ave.
Asst. Prof. of Bacteriology. (1921).
B. S., Purdue U., 1914; M. S., Penn. State College, 1917.
Instr. in Botany, Penn State, 1915-18; Asst. in Animal Path-
ology, Veterinary Dept., Purdue U., 1918-20; Logan Fellow
and Asst. in Bacteriology, Univ. of Chicago, 1920-21.
Soc. Amer. Bacteriol.; Sigma Xi.
Swine Dysentery, Purdue Agr. Exp. Sta. Bull., 1921, 257.
Observations on Paratyphoid Bacilli Recently Isolated from
Animals. Jour. Infect. Dis., 1920, 26, 4, p. 340-346.
Infectious Abortion of Swine. JJour. Infect. Dis., 1920, 27,
2, p. 165-168.
Paratyphoid Bacilli from Chicks. (Spray and Doyle, L. P.).
Jour. Infect. Dis., 1921, 28, 1, p. 43-47.
Pathogenic Bacteria in Hog Cholera Blood. (Spray and
Doyle). Jour. Infect. Dis., 1920, 27, p. 245-249.
Pneumonia in Swine. (In press). Jour. Infect. Dis.
- SUTTON, LUTHER F.**, Wardensville, W. Va.
Supt. and Asst. Horticulturist, Reymann Mem. Experiment
Farms (1921).
B. S., Salem College, 1906; B. S., Agr., U. of Wisconsin,
1912.
- TILTON, JOHN L.**, 41 Euclid Ave. 969-M.
Assoc. Prof. Geology. (1920).
B. A., Wesleyan U., Middletown, Conn., 1885; M. A., Wesleyan
U., Conn., 1888; M. A., Harvard U., 1895; Ph. D., U. of
Chicago, 1910.
Asst. in Natural History, Wesleyan U., Conn., 1886-88; Prof.
of Geology and Physics, Simpson College, 1888-1920; Fellow
in Geology, U. of Chicago, 1902-03.

- A. A. A. S.; Geological Soc. of Amer.
The Thurman-Wilson Fault through Southwestern Iowa.
Jour. of Geology. 27.
Geological Section along Middle River in Central Iowa.
Iowa Geological Survey, 3 p. 135-146.
On the Southwestern Part of the Boston Basin. Proc. Bos.
ton Soc. of Natural History. 26.
The Area of Slate near Nashua, N. H. Proc. Iowa Acad. of
Sci. 3, p. 66-71.
The Geology of Warren County, Iowa. Iowa Geo. Survey.
5, p. 303.
Part of the Geology of Madison County, Iowa. I. G. S., 7,
p. 491-539.
Results of Recent (1896) Geological Work in Madison Coun-
ty. I. A. S., 14, p. 47.
Engineering Problems in a Course in Physics. Science, 22,
p. 141-148.
A Problem in Municipal Waterworks for a small City. Proc.
I. A. S., 12, p. 143-150.
An Attempt to Illustrate Tides and Tidal Action. Proc. I. A.
S., 13, p. 30.
Science Required for a General Education. Proc. I. A. S.,
15, p. 13-15.
The Pleistocene Deposits of Warren County, Iowa. The U.
of Chicago Press. 1911.
The Pleistocene Record of the Simpson College Well. Proc.
I. A. S., 17.
The Hydrographic Relations in Warren County. Iowa. I.
G. S., 21, p. 991-998.
The First Reported Petrified American Lepidostrobus Proc. I.
A. S., 19, p. 163.
The Proper use of the Geological Name, 'Bethany'. Proc.
I. G. S., 20, p. 207.
A Pleistocene Section from Des Moines South to Allerton.
Proc. I. A. S., 20, p. 213.
A New Section South from Des Moines, Iowa. Science, 38,
p. 133-135.
An Area of Wisconsin Drift Southwest from Des Moines.
Proc. I. G. S., 21, p. 219-220. Also 22, p. 229.
The Age of the Terrace South of Des Moines. Proc. I. A.
S., 22, p. 233.
Records of Oscillations in Lake Level. Proc. I. A. S., 23, p.
91., and also 24, p. 33.
The Geology of Clarke County, Iowa. I. G. S., 27.
The Geology of Cass County, Iowa I. G. S., 27.
The Geology of Adair County, Iowa. I. G. S., 27.
Awaiting Publication:—The Subdivisions of the Missouri
Stage in Southwestern Iowa.
The Area near Stuart Iowa.

TORREY, MARIAN M., 116 Beverly Ave. 873-W.

Instr. Mathematics (1920).

B. A., Brown U., 1916; M. A., Brown U., 1917.

Sigma Xi; Mathematical Assoc. of America.

VAN LIERE, EDWARD J., 79 Grant Ave. 368-R.

Prof. of Physiology. (1921).

B. A., U. of Wisconsin, 1915; M. S., U. of Wisconsin, 1916;

M. D., Harvard, 1920.

Asst. in Zoology, U. of Wis., 1914-16; Asst. in Physiol., U. of Chicago, 1917-18; Acting Prof. of Physiol. and Pharm., U. of S. Dakota, 1920-21.

Intestinal Parasites of Foreign Students. Jour. A. M. A.

WAGGONER, CHAUNCEY W., 730 University Terrace. 968-M.

Prof. Physics. (1909).

B. S. E. E., Ohio U., 1904; M. A., Cornell, 1905; Ph. D., Cornell, 1909.

Instr. in Physics, Cornell, 1905-09.

A. A. A. S.; Am. Phys. Soc.; Inst. of Radio Engineers; Ill. Eng. Soc.; A. A. U. P.; Am. Soc. for Testing Material.

The effect of Low Temperature on Some of the Physical Properties of a Series of Iron-Carbon Alloys. Physical Review, 28, p. 393.

Some Studies in Short Duration Phosphorescence. Physical Review, 27, p. 209.

A Study of the Elastic Properties of a Series of Iron-Carbon Alloys. (With C. R. Jones). Proc. Am. Soc. for Test. Mat., 1, p. 492.

Some Phosphorescent Salts of Cadmium and Sodium. Physical Review, 31, p. 358.

A Relation between the Elastic and Magnetic Properties of a Series of Unhardened Iron-Carbon Alloys. Phy. Review, 35, p. 58.

The Heat of Fusion of Tin. School Sci. and Math. 13 p. 669.

Chapters on The Preparation of Phosphorescent Salts, and Experiments in Short Decay Phosphorescence. Studies in Luminescence, Carnegie Inst. for Research, Washington, D. C., 1911.

A Study of Low and Short Aerials for Rado Telegraphy. Science. 26.

The Elastic and Magnetic Properties of Iron and Steel. Inter. Conference for Testing Materials, Brussels, Belgium, 1918

High School Physics. Dept. of Free Schools, 1911.

A Physiological Recorder for Radio Time Signals. Physical Review. 5.

- A Simple Gas Meter for Use with the Junker Calorimeter and Testing Gas Meters. (With J. W. Hake). School Sci. and Math. 15, p. 571.
- The Tribo-Luminescence of Some Salts of Zinc with Willemite. Physical Review, 1916.
- The Kathodo-Luminescence of Tribo-Luminescence Compounds. Physical Review. 1917.
- Prescription Scales, Weight and Graduated Glassware. The Midland Jour. 1917.
- Images on Silvered Photo-Plate. Physical Review, New Series, II.
- The Suppression of Hysteresis in Iron-Carbon Alloys by a Longitudinal Alternating Magnetic Field. (With H. M. Freeman). General Electric Review, 1918, 21, p. 143.
- Anhyseteric Curves of Iron-Carbon Alloys Made with a Braun Tube. (With F. A. Molby). Physical Review, 1921.
- Work now in progress:
- Hints on the Radio Phone.
- A Study of the viscosity and temperature of a double silicate of Calcium and Sodium.
- Refractometers and Polariscopes as control instruments in the manufacture of glass.
- The Eddy Current and Hysteresis loss in Silicon Steel at high frequencies. (With F. A. Molby).
- WALLS, HOY J.**, 7 So. High St. 1368-J.
Instr. Electrical Engineering. (1921).
B. S. E. E., W. V. U., 1920.
American Institute of Electrical Engineers.
- WEAKLEY, CHARLES E.**, Jr., Morgantown. 7124-R5.
Asst. Chemist, Agr. Exp. Sta. (1907).
Bulletins, W. Va., Agr. Exp. Sta. (See list).
Amer. Assoc. of Instructors and Investigators in Poultry Husbandry.
- WESTOVER, KYLE C.**, 741 N. Front St.
Asst. Prof. Horticulture. (1921).
B. S., New Hampshire College, 1917.
Asst. in Horticulture, U. of Kentucky, 1920-21.
Amer. Soc. of Horticulture.
- WHARTON, RAY H.**, 63 Kingwood St. 949-M.
Asst. in Anatomy and Histology. (1921).
B. S., W. V. U., 1921.
- WHITE, B. S.**, 115 Quay Ave. 873-M.
Asst. Prof. Drawing. (1919).
B. S. M. E., W. V. U., 1897.

- WILSON, CHARLES V.**, 234 Prospect St. 731-R.
Instr. Animal Husbandry and College of Agr., Asst. in Animal Hus. W. Va., Agr. Exp. Sta. (1919).
B. S., Agr., W. V. U., 1919.
- WINTER, J. E.**, 238 Richwood Ave.
Asst. Prof. Psychology. (1921).
B. A., Hope College, 1902; M. A., U. of Michigan, 1910; Ph. D., U. of Michigan, 1917.
Asst. Prof. of Psychology, U. of N. Dakota, 1915-16; Prof. of Psychology and Education, Parsons College, Iowa, 1916-21
Nat. Educ. Assoc.; Soc. of College Teachers of Education.
Sensation of Movement. Psychological Review, 1912.
The Moral Ideal in Education. Mich. Schoolmaster, 1917.
The nature of Moral Education. Quarterly Journal, 1916.
Moral Education in Cyril, Augustine, Jerome and Cassian.
Thesis to be published.
- YORK, HARLAN H.**, 234 Jackson Ave. 1185.
Prof. of Botany, (1919).
B. S., De Pauw U., 1903; M. A., Ohio State U., 1905; Ph. D., Johns Hopkins, 1911.
Fellow in Botany, Ohio State U., 1903-04; Asst. Botany, Ohio State U., 1904-05; Fellow in Botany, Columbia U., 1905-06; Instr. Botany, U. of Texas, 1906-09; Asst. Botany, Johns Hopkins, 1909-11; Asst. Prof. Botany and head of Dept., Brown U., 1911-19; Forest Pathologist, Office of Forest Pathology, U. S. Dept. Agr. 1916.
A. A. A. S.; Botanical Soc. of Amer.; Phytopathological Soc. of Amer.; New England Botanical Club; Sigma Xi.
Agar-agar method for Embedding Plant Tissues. Jr. Applied Microscopy, and Laboratory Methods, 1903, 6, p. 2591-92.
Agar-agar and Paraffin Method for Embedding Plant Tissues. Ohio Naturalist 1905.
A New Aspidiotus from Ohio. Ohio Naturalist, 1905.
Hibernacula of Ohio Water Plants. Ohio Nat., 1905, 5, p. 291-94.
The Development of the Embryo-Sac and Embryo of Nelumbo lutea. Ohio Naturalist, 1904, 4, p. 167-176.
The Anatomy and some of the Biological Aspects of the "American Mistletoe" *phoradendron flavescens* (Pursh) Nutt. Bull. U. of Texas 1909, 120, 13.
The Origin and Development of the Embryo Sac and Embryo of *Dendrophthora opuntoides* and *D. Gracile*. Botanical Gazette, 1913, 54, p. 89-111 and 200-216.
Some Observations on the Sexuality of *Spirogyra*. Science, N. S., 1913, 38, p. 368-369.
The Relations of the Distribution of Plants to Tide Levels. (Joint Author), Carnegie Publication, 206.

- The Overwintering of *Cronartium Ribicola* on *Ribes*. (Joint Author), *Phytopath.* 1918, 8, p. 617-619.
- Experiments in the Infection of *Pinus Strobus* with *Cronartium Ribicola*. (Joint Author). *Phytopath.* 1922, (In press).
-

BULLETINS PUBLISHED BY THE WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION.

1. Organization and Work of the Station. (John A. Myers, Director).
2. The History, Properties, Source of the Ingredients, Mode of Application, and Uses of Commercial Fertilizers. (A. R. Whitehill).
3. Prepared under the Auspices of the West Virginia Agricultural Experiment Station. (W. D. Doan).
4. The Creamery Industry: Its Adaptability to West Virginia. (A. C. Magruder).
5. The Selection of Milch Cows. (A. C. Magruder).
6. Six months Experience in Running a Creamery. Improved Process of Handling Cream and Churning. (John A. Myers, Director).
7.
 - I. Experiments upon wheat.
 - II. Experiments upon fruit trees.
 - III. Experiments upon garden seeds, etc.
 - IV. Experiments upon grasses and forage crops.
 - V. Experiments upon miscellaneous subjects. (John A. Myers).
8. Summary of Meteorological Observations, and Reports of Correspondents on Conditions of Agriculture, etc., in the State. (John A. Myers).
9.
 - I. Additional Reports upon Wheat Distributed in 1889.
 - II. Meteorological Report for July.
 - III. Reports of Correspondents upon Meteorology and Crops for July. (John A. Myers).
10.
 - I. Meteorological Report for August.
 - II. Reports of Correspondents upon Meteorology and Crops for August. (John A. Myers).
11.
 - I. Meteorological Report for September.
 - II. Reports of Correspondents upon Meteorology and Crops for September. (John A. Myers).
12. The Canada Thistle. (C. F. Millsbaugh, Md. Botanist and Microscopist).
13. The Creamery Industry. (John A. Myers).
14.
 - I. Farm and Garden Insects, and Experiments with Remedies.
 - II. Notes of the Season. (A. D. Hopkins).
15. Raspberry Gouty-Gall Beetle. (A. D. Hopkins).
16. Preliminary Investigation of Insect Ravages. Yellow Locust. (A. D. Hopkins).

17. Preliminary Report. Black Spruce. (A. D. Hopkins).
18. Law and Regulations Concerning the Sale of Commercial Fertilizers in the State of West Virginia. Analyses.
Conclusion. 27 per cent of the Commercial Fertilizers Sold in West Virginia Below the Manufacturer's Guarantee. (John A. Myers).
19. Your Weeds and Your Neighbor's. Part I.
Weeds as Fertilizers. (C. F. Millspaugh).
20. Potato Culture, and Fertilization, and Tests of some Varieties of Tomatoes. (D. D. Johnson).
21. Injurious Insects and Plant Diseases. (A. D. Hopkins, and C. F. Millspaugh).
22. Your Weeds and Your Neighbor's. Part II.
Distribution of our Weeds.
Bad Points of Weeds.
Weeds as Fodder for Stock.
Chemical Weed Exterminators (C. F. Millspaugh).
23. Your Weeds and Your Neighbor's. Part III. Illustrated Descriptive List of Weeds. (C. F. Millspaugh).
24. Flora of West Virginia. (C. F. Millspaugh).
25. Plat Experiments with Commercial Fertilizers on Wheat. (D. D. Johnson).
26. Law and Regulations Concerning the Sale of Commercial Fertilizers in the State of West Virginia. Analyses. (John A. Myers).
27. Notes on Pruning. (F. Wm. Rane).
28. Plat Experiments with Commercial Fertilizers on Corn. (D. D. Johnson).
29. I. Experiments on Potatoes at the Station.
II. Experiments on Corn at the Out-Station. (D. D. Johnson).
30. Address and Notes on Sheep. (A. D. Hopkins).
31. Catalogue of West Virginia Scolytidae and their Enemies. (A. D. Hopkins).
32. Catalogue of West Virginia Forest and Shade Tree Insects. (A. D. Hopkins).
33. Sub-Irrigation in the Greenhouse. (F. Wm. Rane).
34. Fertilizer Analyses for the Year Ending December 31, 1893. (Dr. R. J. J. DeRoode).
35. Defects in Wood Caused by Insects. (A. D. Hopkins).
36. Black Holes in Wood. (A. D. Hopkins).
37. Electro-Horticulture with Incandescent Lamps. (F. Wm. Rane).
38. Potatoes. Potato Blight, Potato Scab. (F. Wm. Rane).
39. Vegetables. (F. Wm. Rane).
40. Commercial Fertilizers. (B. H. Hite).
41. Potatoes. (L. C. Corbett).
42. Vegetables. (L. C. Corbett).
43. Why, When, What and How to Spray. (L. C. Corbett).
44. Practical Entomology. Insects Injurious to Farm and Garden Crops. The Character of the Injury. The Insect Causing it. The Remedy. (A. D. Hopkins and W. E. Rumsey).

45. Chickens. (Dr. John A. Myers).
46. Fertilizer Analyses. (B. H. Hite).
47. Apples. (L. C. Corbett).
48. Raspberries. (L. C. Corbett).
49. Vegetables. (L. C. Corbett).
50. The Periodical Cicada in West Virginia. (A. D. Hopkins).
51. Commercial Fertilizers. (B. H. Hite).
52. Strawberries. (L. C. Corbett).
53. Commercial Fertilizers. (J. H. Stewart and B. H. Hite).
54. Nursery Hints. (L. C. Corbett).
55. Sugar Beet Investigation in 1898. (J. H. Stewart and B. H. Hite).
56. Report on Investigations to Determine the Cause of Unhealthy Conditions of the Spruce and Pine from 1880-1893. (A. D. Hopkins).
57. Commercial Fertilizers. (B. H. Hite and T. F. Watson).
58. The Effect of Pressure in the Preservation of Milk. A Preliminary Report. (B. H. Hite).
59. Whole Corn Compared with Corn Meal for Fattening Hogs. (J. H. Stewart and Horace Atwood).
60. Poultry Experiments. (J. H. Stewart and Horace Atwood).
61. Sheep Feeding Experiments. (J. H. Stewart and Horace Atwood).
62. A Study of the Effect of Incandescent Gas-light on Plant Growth. (L. C. Corbett).
63. Commercial Fertilizers. (J. H. Stewart and B. H. Hite).
64. Sugar Beet Investigation in 1899. (J. H. Stewart and B. H. Hite).
65. Commercial Fertilizers. (J. H. Stewart and B. H. Hite).
66. Fruit Diseases and How to Treat Them. (L. C. Corbett).
67. The Hessian Fly in West Virginia and How to Prevent Losses From its Ravages. (A. D. Hopkins).
68. The Periodical Cicada or Seventeen-Year Locust in West Virginia. (A. D. Hopkins).
69. Report on Examination of Wheat Stubble from Different Sections of the State. The Joint Worm in Wheat in the Northern Panhandle and Northern Borders of the State. (A. D. Hopkins).
70. Spraying—Results of the Season, 1900. (L. C. Corbett).
71. Poultry Experiments. (J. H. Stewart and Horace Atwood).
72. Commercial Fertilizers. (J. H. Stewart and B. H. Hite).
73. Poultry Experiments. Loss of Weight in Eggs During Incubation. (J. H. Stewart and Horace Atwood).
74. Cold Storage. (L. C. Corbett).
75. Apple Districts of West Virginia. (L. C. Corbett).
76. Commercial Fertilizers. (J. H. Stewart and B. H. Hite).
77. The New Fertilizer Law. (J. H. Stewart).
78. Treatment for San Jose Scale. (J. H. Stewart).
79. Commercial Fertilizers. (J. H. Stewart and B. H. Hite).
80. Fertilizers. Part I—Sources and Composition. (B. H. Hite).
81. Vegetable Gardening in the Mountain Glades. (L. C. Corbett and K. C. Davis).
82. Peach Growing in West Virginia. (K. C. Davis).

83. Poultry Experiments. A comparison of Beef Scraps, Ground Fresh Meat and Bone, and Milk Albumen as Sources of Protein for Laying Hens. (J. H. Stewart and Horace Atwood).
84. Experiments with Buckwheat and Oats. (J. H. Stewart and Horace Atwood).
85. Commercial Fertilizers. Complete Report for 1902. (J. H. Stewart and B. H. Hite).
86. Cranberries in West Virginia. (L. C. Corbett).
87. Greenhouses. (L. C. Corbett).
88. Poultry Experiments. Mash Compared with Whole Grain, and Heavy Feeding Compared with Light Feeding as Affecting the Number of Eggs and their Hatchability. (J. H. Stewart and Horace Atwood).
89. Rural Water Supply with a Study of the Monongahela River Supply at Morgantown. (C. D. Howard).
90. Sheep Feeding Experiments. Notes on Parasites. (J. H. Stewart and Horace Atwood).
91. Commercial Fertilizers. Report for 1903. Part I. From January 1st to May 1st. (J. H. Stewart and B. H. Hite).
92. Commercial Fertilizers. Part II. (J. H. Stewart and B. H. Hite).
93. Mixtures and Appliances for Spraying. (T. C. Johnson).
94. Diseases of Melons and Cucumbers. (John L. Sheldon).
95. Commercial Fertilizers. (J. H. Stewart and B. H. Hite).
96. A Report on Plant Diseases of the State. (John L. Sheldon).
97. Commercial Fertilizers. (J. H. Stewart and B. H. Hite).
98. Raising Chicks Artificially. (J. H. Stewart and Horace Atwood).
99. Experiments with Fertilizers. (J. H. Stewart and Horace Atwood).
100. The Grape Curculio. (Fred E. Brooks).
101. Experiments in the Manuring of a Meadow. (J. H. Stewart and Horace Atwood).
102. Poultry Experiments. The Value of Skim Milk for Egg Production. White Leghorns versus Mongrels. (J. H. Stewart and Horace Atwood).
103. Occurrence of Barium in the Ohio Valley Brines and its Relation to Stock Poisoning. (C. D. Howard).
104. The Ripe Rot or Mummy Disease of Guavas. (John L. Sheldon).
105. Tubercle on Legumes with and Without Cultures. (John L. Sheldon).
106. Feeding Experiments with Milch Cows. (J. H. Stewart and Horace Atwood).
107. A Test of Different Sprays for the San Jose Scale. (W. E. Rumsey and Fred E. Brooks).
108. Commercial Fertilizers. (J. H. Stewart and B. H. Hite).
109. Feeding Grain to Milch Cows at Pasture. (J. H. Stewart and Horace Atwood).
110. The Grapevine Root-Borer. (Fred E. Brooks).
111. Bacteria in Milk and Artificial Refrigeration for Dairymen. (J. H. Stewart and Horace Atwood).

112. Experiments with Fertilizers. (J. H. Stewart and Horace Atwood).
113. Notes on the Habits of Mice, Moles and Shrews. (Fred E. Brooks).
114. Commercial Fertilizers. (J. H. Stewart and B. H. Hite).
115. Poultry Experiments. A Record of Six Hundred Hens. (J. H. Stewart and Horace Atwood).
116. Starting Young Orchards. (W. M. Munson).
117. Tomato Notes. (W. M. Munson).
118. Commercial Fertilizers. (J. H. Stewart and B. H. Hite).
119. The Grapevine Gall-Maker and the Grapevine Girdler. (Fred E. Brooks).
120. Cabbage Worms & Suggestions for Destroying Them. (W. E. Rumsey and Fred E. Brooks).
121. Apple Enemies and How to Fight Them. (W. M. Munson).
122. The Farmer's Home Garden. (A. L. Dacy).
123. Diseases of Garden Crops and Their Control. (N. J. Giddings).
124. Some Factors Influencing the Vigor of Incubator Chickens.
 - I. Age and Vigor of Parent Stock.
 - II. Cooling Eggs During Incubation.
 - III. The Use of Moisture. (J. H. Stewart and Horace Atwood).
125. Commercial Fertilizers. (B. H. Hite and F. B. Kunst).
126. Three Snout Beetles that Attack Apples. (Fred E. Brooks).
127. Spraying for the Codling Moth. (W. E. Rumsey).
128. Snout Beetles That Injure Nuts. (Fred E. Brooks).
129. Construction of a Silo. (Horace Atwood).
130. Construction of a Modern Poultry House and Report of Experiments in Hopper Feeding Laying Hens. (Horace Atwood).
131. Plant Experiments with Fertilizers. (J. H. Stewart and Horace Atwood).
132. Commercial Fertilizers. (B. H. Hite and F. B. Kunst).
133. Suggestions for Spraying. (W. E. Rumsey, N. J. Giddings and A. L. Dacy).
134. Experiments in the Production of Sanitary Milk. (Horace Atwood and N. J. Giddings).
135. West Virginia as a Poultry State. (Horace Atwood).
136. The Apple Orchard from Planting to Bearing Age. (Arthur L. Dacy).
137. The Chestnut Bark Disease. (N. J. Giddings).
138. Commercial Fertilizers—Inspection 1911. (B. H. Hite and F. B. Kunst).
139. Packing Apples and Peaches. (W. H. Alderman).
140. Potato Culture in West Virginia.
 - I. Possibilities as a Truck Crop.
 - II. Essentials of Culture. (Arthur L. Dacy).
141. The Rejuvenation of Old Orchards. (W. H. Alderman).
142. Fertilizer Experiments with Tomatoes. (Arthur L. Dacy).
143. A Market Garden and Truck Survey of the Ohio and Kanawha River Valleys. (A. L. Dacy).
144. Agricultural Production in West Virginia. (O. M. Johnson).

145. Some Factors Affecting the Weight, Composition and Hatchability of Hen Eggs. (Horace Atwood).
146. The Effect of Pressure on Certain Micro-Organisms Encountered in the Preservation of Fruits and Vegetables. (B. H. Hite, N. J. Giddings and Chas. E. Weakley, Jr.).
147. An Orchard Survey of Jefferson County. (R. R. Jeffries).
148. A Poultry Survey of Jackson County. (F. S. Jacoby).
149. Small Fruits for Home and Commercial Planting. (L. F. Sutton).
150. The Fertilization of Peach Orchards. (W. H. Alderman).
151. An Apple Orchard Survey of Berkeley County. (E. C. Auchter).
152. White Burley Tobacco. (I. S. Cook and C. H. Scherffius).
153. An Agricultural Survey of Brooke County. (O. M. Johnson and A. J. Dadisman).
154. Apple Rust. (N. J. Giddings and Anthony Berg).
155. Experiments with Fertilizers. (Firman E. Bear).
156. A Second Report on the University Farm Garden. (A. L. Dacy).
157. Silos and Silage. (E. W. Sheets and G. L. Oliver).
158. The Apple as Affected by Varying Degrees of Dormant and Seasonal Pruning. (W. H. Alderman and E. C. Auchter).
159. Methods in Soil Analysis. (Firman E. Bear and Robert M. Salter).
160. The Residual Effects of Fertilizers. (Firman E. Bear and Robert M. Salter).
161. Analysis of one Hundred West Virginia Soils. (Firman E. Bear and Robert M. Salter).
162. Five Years' Investigations in Apple Thinning. (E. C. Auchter).
163. Amount and Cost of Labor Required for Growing Crops in West Virginia. (O. M. Johnson and A. J. Dadisman).
164. Pruning Fruit Trees. (W. H. Alderman and E. C. Auchter).
165. Potato and Tomato Diseases. (N. J. Giddings).
166. Certain Characteristics of Hen Eggs. (Horace Atwood and Chas. E. Weakley, Jr.).
167. Orchard Spraying Versus Dusting. (N. J. Giddings).
168. Analyses of West Virginia Soils. (Robert M. Salter and Clarence F. Wells).
169. A Study of the Factors Governing the Efficiency of Distribution and Rate of Discharge of Spray Nozzles. (H. L. Crane).
170. Infection and Immunity in Apple Rust. (N. J. Giddings).
171. Experiments with Buckwheat. (F. W. Stemple).
172. Soybean Experiments. (F. W. Stemple).
173. A Two-Year Farm Management Survey of Greenbrier and Monroe Counties. (A. J. Dadisman and C. F. Sarle).
174. The Fertilization of Apple Orchards. (W. H. Alderman and H. L. Crane).
175. West Virginia Trees. (A. B. Brooks).
176. French Creek as a Rural Community. (A. J. Dadisman).

RESEARCH IN ENGINEERING

BY ROLAND P. DAVIS*

Professor of Hydraulic and Structural Engineering. West Virginia University College of Engineering.

To appreciate the position which research occupies in engineering one has only to briefly review the development of engineering as a science and art. Broadly speaking, engineering may be defined as the utilization of the materials and the forces of nature for the benefit of mankind. Such utilization should result in the maximum of benefit with a minimum expenditure of nature's resources.

As a science engineering dates back hardly more than half a century. In 1825 Rensselaer was the only school in the country offering an engineering course and the work offered was of the most elementary character. So rapid has been the development of this profession, due mostly to research work, that at the present time it is estimated that there are about one hundred good engineering schools in the United States with a total enrollment of 50,000 students.

In the early days engineering was entirely military in character. Later when engineering work was carried on for the benefit of civilians, the men doing this were called civil engineers. This work was confined to crude surveying, the construction of roads, bridges, canals, and water supplies. As the field of engineering gradually broadened, those who specialized along the line of power development and machine construction became known as mechanical engineers. Still later as research gave us more and more knowledge in the field of electrical phenomena, the mechanical engineer specializing along this line became known as the electrical engineer.

In a similar manner the civil engineer who specialized in mining and metallurgy became the mining engineer. Within the last twenty years another highly important branch of engineering has developed—chemical engineering. This branch has developed not so much from a branching off from the parent stem, civil engineering, as by a combination of chemistry with engineering.

In 1847 Squire Whipple of Utica, New York, first enunciated the correct principles of stress distribution in framed structures

and laid the scientific foundation for the design of all kinds of framed structures. Prior to that time, the timber truss bridge, many of which still exist in West Virginia, was built by empirical rules, which resulted either in structures decidedly weak at certain points or else wasteful in the use of material. Such rule of thumb methods were not entirely unsatisfactory as long as structures were small. By scientific investigation in less than three-quarters of a century we have advanced from the small bridge of 150-foot span to the famous Quebec bridge with its channel span of 1800 feet and total length of 3239 feet and from the small two or three story building to the Woolworth Building with its 55 stories and height of 750 feet.

But this advance has not been made without some heart-breaking failures. In the building of the Quebec Bridge, twice did the structure fail before success finally crowned the efforts of its engineers. The first failure was due to a lack of scientific knowledge on the action of large compression members. This failure led to the building of a compression-testing machine by the United States Bureau of Standards capable of testing destruction columns with a strength of ten million pounds. Tests since made on this machine have wonderfully advanced our knowledge of column action.

That the field of structural engineering is still full of unsolved problems is evident from the death roll continually resulting from the failure of engineering structures. West Virginia, with its multitude of rivers which eventually will have to be bridged may profitably invest something to help reduce such failures.

One of the most common failures is that of retaining walls. Is there anyone who has not seen such a failure? In spite of the fact that walls have been built since the beginning of time, there is not an engineer today who can figure the actual earth pressure on the back of a wall.

Today millions of dollars are spent annually on reinforced-concrete structures, yet twenty-five years ago such structures were unknown and the theory of design entirely undeveloped. The development of this field has been largely due to the research work done in the laboratories of a few universities. The engineering experiment station of the University of Illinois has been a leader in this field and too much credit can not be given it for benefits it has conferred to mankind in its research work in concrete.

West Virginia is just embarking on a good roads program in which the initial expenditure will be fifty million dollars. A goodly portion of this money will be expended on concrete surfacing. Yet anyone who has observed the wearing qualities of concrete will be impressed with the need of making better concrete. Here, indeed, is a fruitful field for research work.

More and more emphasis is being placed on preventive medicine and less on curative medicine. Preventive medicine is closely connected to sanitary engineering and in fact it is probable that society owes as much, if not more, to the engineering profession than to the medical profession in improving the public health. The dream of the future is the elimination of disease with its tremendous cost in money and suffering and, from the progress that has already been made in the eradication of such diseases as malaria and yellow fever and the control of typhoid, there is no reason why this dream should not become a reality. Twenty years ago the typhoid death rate in the city of Pittsburgh was 116 and today it has been reduced to 6 per year. On this basis the death rate in a city the size of Morgantown should be less than one death from typhoid fever annually. This wonderful reduction has been brought about mainly through the agency of water purification. The slow sand filter, one of the most reliable types, will remove over 99 per cent of the disease germs in water. Will further research develop a method of eliminating the last one per cent at a reasonable cost?

West Virginia has a priceless heritage in its potential water power. Coal, oil, and gas are gradually being depleted, and once gone are lost forever as sources of power development in this state. On the other hand we can use water power today and still have it tomorrow. With more than forty horse power per square mile of area, West Virginia ranks fifth among the states in available water power per square mile and eleventh in the total water power available. In development it ranks twenty-ninth, only about five per cent having been developed up to the present.

The hydraulic turbine is one of the most efficient of prime movers. With steam power only about six or seven per cent of the energy present in the fuel becomes available as useful power while in some of the present large hydro-electric developments efficiencies as high as 93 per cent are obtained. Such high efficiency is due to the careful research work done in turbine design during

the past fifteen years. Twenty years ago an efficiency of 70 per cent was considered very good. West Virginia has a minimum potential horse power of about one million. An increase of efficiency from 75 to 90 means an increased value of power amounting to more than twenty million dollars annually. Such high efficiencies as above noted are possible only under limited variations in working conditions. The problem of the future is to design a turbine which will have high efficiencies under a wide range of working conditions.

In the field of power engineering radical developments have taken place in the last few years. Probably the greatest advance has been in the development of higher efficiencies in the steam boiler. Originally set only two or three feet above the fire, boilers are now set as high as twelve feet or more; likewise the volume of combustion space has reached two to twelve cubic feet for each square foot of grate area. Much research work has been done on the subject of smoke elimination and it now seems that mechanical stokers will be the final solution of the problem. At the present time the under-feed stoker is perhaps most widely used but the chain-grate stoker is seriously contesting its supremacy.

The steam turbine has had a most picturesque development and single units furnishing 70,000 K. W. are being built, which, allowing for the generator efficiency and the mechanical efficiency of the turbine, means an indicated horse power of 112,000. A single unit of this size uses cooling water equal in amount to the water supply of a city of 300,000 population.

One hears much discussion among engineers of super-power zone stations, the construction of which, it is estimated, will save annually sixty million tons of coal in the region comprising Boston to Washington and west to Niagara Falls. By such an arrangement a large number of small unit, low efficiency power houses will be replaced by a few super-size units connecting intimately the largest industrial section of the United States. With the placing of these central stations near the sources of fuel supply a tremendous transportation burden would be relieved.

Compounding, superheating, heating of feed water, the use of mechanical stokers and pulverized fuel furnaces have all contributed a share in increasing the efficiency of the notoriously wasteful railway locomotive. This increase in efficiency amounts to as much as twenty-five per cent in some cases.

The internal combustion engine has recently been developed into a compound engine. The air is compressed in two stages to a pressure exceeding that used in the Diesel engine and the expansion is carried down through several cylinders. These engines have been built with a weight of only thirty pounds per horse power while the Diesel weighs about four hundred and fifty pounds per horse power.

To the researches of Galvani and Volta we owe our first knowledge of electric batteries and to Faraday of the principles of the dynamo and electric motor. However, if the work of these pioneers had not been followed up by experimental research in university and manufacturing laboratories we would not today have the great development of electrical apparatus which makes possible the convenient and economical use of power.

While at the present time it may seem a simple matter to talk over long distance yet it was due entirely to the research work done by Professor Pupin at Columbia University that made possible the holding of conversations by persons at distances over five hundred miles apart. Likewise the research work of many scientists in university and other laboratories on the theory of vacuum tubes has made possible our transcontinental and wireless telephony.

The electric propulsion of ships and the electrification of railroads are problems now occupying the interests of many electrical engineers. It is estimated that the electrification of our railways will not only result in a vastly decreased consumption of coal but will also result in doubling the tonnage now carried by the railways.

The super-power zone system mentioned elsewhere will necessitate the carrying of electric current under enormously high voltages, for only under high voltages can electric current be carried long distances economically. This will open up new fields in transmission problems as the proper insulation of the lines will be one of the biggest undertakings and will necessitate a large amount of theoretical and experimental investigation of the dielectric circuits.

The rule for the economical transmission of power is approximately 1000 volts per mile length of line. At the present time maximum voltages used are 220,000 but the future will probably see the necessity for voltages from 500,000 to 1,000,000.

Back in the early eighties we had the beginning of the modern incandescent lamp. The first lamp which was brought out by Edison in November 1880 was made of carbonized bamboo filaments enclosed in a glass bulb blown from one inch glass tubing. This lamp requires 5.8 watts per candle power and was of 16 candle power. It was early recognized that while this was a desirable form of light, it was too inefficient, so research work was carried on to improve the lamp. The first improvement was using in place of bamboo a filament of carbonized cellulose made by dissolving absorbent cotton in zinc chloride and hardening it in alcohol. This gave a lamp of 3.1 watts consumption or only about half the power consumption of the first lamp. Later improvements in the carbon lamp brought its efficiency to 2.5 watts per candle power.

The biggest step in the advance of incandescent lamps was the substitution of metallic filament for the carbon in which we get, using a bulb containing an inert gas with a tungsten filament, a consumption of only 0.5 watts for a lamp of 2,000 candle power. Thus gaining in efficiency over 1100%.

This great development in the lamp is due entirely to research work in various laboratories and it is possible that through the continued scientific research we may approach the efficiency of the glow worm which makes its light so efficiently that it is not accompanied by heat as in other sources of light.

Due to the improvements in the lamp alone the cost of lighting has been reduced to about 7% of what it cost with the first lamps. While with the improvements in the generation of electrical energy together with the lamp improvements the cost of lighting has been reduced to about 3% of what it cost at first.

"Research" is a word seldom mentioned in connection with coal mining and for that reason many people have assumed that the industry has no use for research. Nevertheless, an industry which has increased its production to meet a demand for coal of about six tons per person per annum as compared to one ton in 1880, and has done it with a decreased number of working hours per day; an industry which had adopted and put in successful operation an underground electric haulage system before our first real street railway was in operation; an industry which has developed several successful types of coal cutting machinery in the last two decades; an industry which has planned underground development, mining methods, transportation and

hoisting equipment to such a degree of perfection as to permit the production and hoisting through a single shaft of over 8200 tons of coal in eight hours; an industry which has done these things is no stranger to research.

The research work which has produced these results has in nearly every case been local experimental work on the part of a mine, or a machinery manufacturing company. Progress under such conditions was, of necessity, slow.

The need for research along coal mining lines is more evident today than ever before. Such research may be classed under three heads: Safety, Production, Utilization.

SAFETY RESEARCH. Coal Mining is a hazardous occupation and one life is lost, on the average, for every 250,000 tons of coal produced. Research work in mine ventilation, the distribution and control of the ventilating current so as to properly and efficiently handle explosive gas, minimizing the dangers due to fine coal dust by investigations as to the best methods of preventing the making and distribution of dangerous dust, means of humidification, etc., is greatly needed. Special attention must be given to methods for preventing accidents from falls of roof and coal and those occurring on the haulage system, for three out of every four men killed meet their death in these ways. While the value of human life cannot be estimated, yet if we take \$3000, the sum frequently awarded by compensation insurance, as representing the minimum estimate of the value of a man's life, this country loses more than \$6,000,000 every year on account of fatal accidents in coal mining. Research work in mine safety will pay big dividends besides conserving human life and happiness.

PRODUCTION RESEARCH. The coal industry is frequently criticized for its wasteful use of human labor—the use of man power instead of mechanical power. Great forward steps have been taken in bettering this condition, as, for example, the use of coal-cutting machinery and modern haulage appliances. The next great step will be the application of loading machines. Much research work must be done along this line, not only with respect to the machines themselves, but more especially to the development of new methods of working that will permit these machines to operate at maximum capacity.

Increased percentage of recovery is necessary for the economical use of our coal supply. In many cases less than 50 per cent

of the coal is recovered. Production methods with control of surface subsidence must be developed so as to permit a higher percentage of extraction.

UTILIZATION. The increasing use of coal is serving to call attention to our wasteful use of valuable fuel. The wasteful bee-hive coke oven is usually cited as an example of waste, but it is rapidly being relegated to a back place, almost 80 per cent of the coke produced in 1921 being made in the by-product ovens. But the burning of coal under boilers is just as wasteful an operation as making coke in a bee hive oven, and research must point the way to a more efficient production of power from fuel.

The utilization of our poorer coals, the preparation of coal by washing or air separation so as to make it suitable for by-product or special purpose uses, suitable methods of coal storage that will eliminate the danger of spontaneous combustion, the use of fine coal for the manufacture of briquettes are among the many research problems awaiting solution.

Only a few of hundreds of research problems have been mentioned, and these have all been of direct practical application. There is also a field of research along lines that may seem at present of only scientific importance but which will ultimately mean a great deal to the industry. For example, the work which is being done in determining the constitution of coal by means of the microscope will likely be of considerable importance in correlating coal seams. Likewise the study of the forms in which sulphur occurs in coal is of immediate importance as a factor in coal washing and may have a direct bearing on coke manufacture.

West Virginia will benefit greatly from any research work which is done in coal mining engineering, for coal is its chief natural resource. At the present rate of mining improvements in the art that would amount to a saving in the cost of mining of but one cent a ton would mean a total of \$100,000, while the tangible and intangible benefits of safety research would be incalculable.

The history of the development of the modern electric furnace is one of the examples of great practical results from scientific combined with engineering research. Little did Despretz think when he was experimenting in his laboratory with his little electric arc furnace in 1849 that he was starting that series of scientific experiments which would lead eventually to the many great electro-chemical manufactures and centers of in-

dustry which today dot the maps of Europe, North America and are even now spreading to the other continents of the world. Nearly forty years elapsed before Siemens and Huntington, seeking for a method of obtaining higher temperature than were possible to be reached by the usual processes of combustion applied Depretz's discovery, of the high temperatures obtainable with the electric arc, in making the first practical electric furnace. They were able to melt and purify small quantities of tungsten, that element which today is one of the important substances used in making electric light filaments. There were certain defects in the construction of this first furnace but further research has eliminated most of them.

Probably the greatest contribution to the scientific side of electric furnace development has been made by the great French chemist, Henri Moissan. In 1892 he exhibited to l'Academie des Sciences his first model of an electric furnace. In this he used a quick lime lining. From that date on progress both from a scientific and practical point of view has been rapid. Cowles, Grabau, Acheson, and many other chemical and electrical engineers have contributed largely to the present day successful application of electricity to the manufacturing chemical industries.

We will refer briefly to the growth of two electro-chemical industries in America, the manufacture of calcium carbide and of graphite and carborundum. Calcium carbide had been prepared as a laboratory specimen by Edmund Davy in 1836. Moissan first noted the formation of calcium carbide in his lime lined electric furnace in 1892. In this same year Maquenne studied the properties of an impure calcium carbide which he had prepared by the reduction of the carbonates of the alkaline earths with magnesium. In 1893 Travers in England fused a mixture of powdered carbon, sodium and calcium chloride and obtained a black mass which contained as high as 16 per cent calcium carbide. In one of his patents taken out about this time T. L. Willson, an American chemical engineer, refers to an undetermined calcium carbide which was formed in the preparation of an aluminum bronze. He followed up this clue and in 1895 prepared calcium carbide on a commercial scale. It remained, however, for the later hydro electric development of cheaper electrical energy to make the manufacture of calcium carbide a financial success. At present

it is manufactured in large quantities in a modified type of electric furnace.

There are two large centers of the carbide industry in North America; the Shawinigan Water and Power Company of St. Maurice River Falls, Canada; and the carborundum Company and the International Acheson Graphite Company at Niagara Falls.

Many West Virginia miners fill their mine lamps with "Miners Special", calcium carbide, manufactured by the Canada Carbide Company, Limited, Shawinigan Falls, Canada. Yet the coke and lime needed for this industry can be obtained from the coal and limestones in this state as cheaply as anywhere in the world and the potential power in our rivers would, if harnessed, furnish all the hydro-electric energy needed for large manufacturers of this nature within our own state. Last year the sales of calcium carbide, graphite, and carborundum amounted to hundreds of thousands of dollars. West Virginia has an abundance of good sand and sandstone and with the coal from which to secure the coke cheaply it would seem that both graphite and carborundum could also be manufactured in this state at as low a cost as in any other location.

The manufacture of aluminum is another chemical industry which depends for its financial success quite largely upon cheap electrical power. It also well illustrates the value of chemical combined with engineering research in creating great chemical industries, and is one of the more recent advances. Oersted in 1824 and Wohler in 1827 had prepared aluminum as a laboratory curiosity and for a study of its chemical and physical properties. The aluminum industry, however, was established in France in 1854 by Henri Saint-Claire Deville. The industry developed slowly until scientific research led to the discovery that the oxide of aluminum could be easily reduced to the metal by means of the electric current. Many years of patient investigation had been spent on this problem before the American chemical engineer, Charles M. Hall perfected a combined thermo-electric process. This discovery has made possible the abundance of aluminum for the utensils, instruments, alloys, and engineering service at a fairly reasonable price. In 1885 the world's production of aluminum was 283 pounds and the price was \$5.00 per pound; in 1920 the production of this metal in the United States alone was valued at \$41,375,000 at a price of from 17 to

20 cents per pound. The value of the finished product was of course much more, and of related aluminum compounds some \$20,000,000. This industry gives profitable employment to several thousand workmen and its products have added greatly to the conveniences of modern life.

Mr. Hall, the inventor of the Hall Process for manufacturing aluminum, is reported to have bequeathed \$3,000,000 to Oberlin College, the institution where he received his first chemical training. Who would say that the money, time, and effort spent in applied scientific research regarding aluminum and its compounds have not been repaid a thousand fold by the discoveries and applications which have resulted?

There are also great possibilities for biochemical industries in this state. The manufacture of paper and pulp is one of America's few billion dollar industries. The West Virginia Pulp and Paper Company is one of the largest in this country and has plants in this and other states. Many of the hills in this state, too rough for general farming purposes could be utilized by proper reforestation to yield the wood for a perpetual pulp and paper industry in this state. The Agricultural Experiment Station has already published a bulletin on "West Virginia Trees" which might be used as a start for further research on this important problem. The discovery by Dr. Ralph K. McKee of the Department of Chemical Engineering in Columbia University of a yeast which can be used under the conditions he outlines for the fermentation of the sulphite waste liquor from pulp plants and made to produce large quantities of industrial alcohol is one of the recent valuable contributions resulting from the application of research methods applied to the pulp and paper industry.

Scientific studies regarding the uses of glass sands and the manufacture of glass, of ceramics and the utilization of West Virginia clays in the pottery, chinaware and porcelain industries, of limestones and cements would also prove of value to the state in developing industries along these lines. Their further consideration must, however, for lack of space be deferred to another time.

The greatest natural resource of West Virginia is her deposits of bituminous coal. And it behooves the state to make the most of this wealth, for in course of time the stored up supplies will become less and less even as the natural gas and petroleum are

even now greatly diminished. At the present time by far the largest portion of the coal mined in this state is shipped out directly without any processing whatever. Some coal is used for power development within the State and domestic consumption accounts for a little. According to the best reports available, West Virginia produced in 1920 about 87,500,000 tons of coal. Only a very small portion of this was used in by-product ovens, 414,000 tons of byproduct coke being produced. During the same year Pennsylvania mined 163,000,000 tons of bituminous coal and produced 7,710,000 tons of byproduct coke. In comparison Pennsylvania mined somewhat less than twice the amount of coal that we did but utilized in byproduct ovens over eighteen times as much as we did. The value of byproduct coke produced in the United States, in 1919 was \$160,143,787, of this amount West Virginia received only \$1,750,908, yet she was second from the top of the list of states in the production of bituminous coal.

In 1919 West Virginia ranked twenty-seventh among the states in value of manufactured goods produced, being lower than many states far less richly endowed with natural resources. History shows the tendency of manufacturing enterprises to center around the place at which inventions along those particular lines were first developed, even though costs of production may be greater than at other points. This fact should prove an incentive for this state to provide funds for the carrying on of research of a high order at her state university.

The scientific and industrial development of the United States for the last half century reads like a dream. The luxuries of yesterday are the necessities of today. If we are to continue the development, research work at West Virginia University should be fostered and ample funds provided for carrying on the work.

*The writer is indebted to Professors J. B. Grumbein, A. H. Forman, A. C. Callen, and W. W. Hodge for much of the material contained in this article.

THE UNSOLVED PROBLEMS OF MEDICINE*

AARON ARKIN, A. M., M. D., PH D.

Professor of Pathology and Bacteriology, West Virginia University, Morgantown, W. Va.

In ancient times civilizations were born, grew for a few generations and fell into decay. Conquests brought disease, and civilizations were obliterated by contagion. History reveals to us numerous instances in which heroes brought to their rejoicing countries, with their prisoners of war, pestilences which vanquished the victors. The Greeks were unable to cope with malaria, yellow fever and bubonic plague. The medicine of Hippocrates, the philosophy of Plato, and the science of Aristotle could not save Greece from the ravages of disease. The great Roman Empire, which promised to encircle the earth, met with a similar fate. Malaria, yellow fever, smallpox, typhus, cholera, and dysentery have been the destroyers of civilizations and determiners of history. They darkened the world in the Middle Ages, when whole nations went into coma and died.

No scientific knowledge of the causation of disease, and hence of disease prevention and treatment, was possessed by mankind until the last half century. Diseases were thought to be due to the entrance into the body of evil spirits beyond the control of man. We are just emerging from a past in which superstition and mysterious influences were invoked to explain the spread of disease. Man's progress from the marshes of ignorance to the uplands of intelligence has been slow and halting. Even at the present time only a small part of the earth is illuminated by the light of knowledge. Much of it is still covered by clouds of ignorance. Today only one percent of the population of the world has medical care and sanitary regulations. Is it any wonder that epidemic diseases exist, and spread in times of war?

All of this is a matter of great importance, for the successful conquest of disease involves wide co-operation of all the people, and this is impossible without a fair understanding of, and confidence in, the hygienic and sanitary measures necessary for the control and prevention of communicable diseases. Even more important is the education of the public in the conquest of those

*From the Department of Pathology and Bacteriology, West Virginia University School of Medicine.

diseases which our present knowledge and practice of preventive medicine have been unable to control. I mean the unsolved problems of medicine: degenerative diseases of heart, kidney and blood vessels; tuberculosis; cancer; acute respiratory diseases (pneumonia, influenza, scarlet fever, measles, etc.); venereal diseases, and metabolic diseases (diabetes, dietary diseases).

Typhoid fever, cholera, malaria, typhus fever, yellow fever, and hook-worm can be controlled by sanitary measures. We need only to control the environment—purify water supplies, destroy insects, administer quinine, prevent food contamination and these diseases will disappear from any country. But not so with cancer, acute respiratory diseases, tuberculosis, and degenerative diseases of heart, blood vessels and kidney. The latter diseases have been increasing rather than decreasing.

We have conquered many of the infectious diseases (typhoid, cholera, typhus, malaria, yellow fever, rabies, tetanus, diphtheria, smallpox, etc.) by organized administrative efforts at betterment of living conditions, sanitation, immunization, isolation, quarantine and disinfection. We can conquer others by the application of these same principles. But against many of the respiratory tract infections (tuberculosis, influenza, pneumonia, measles, poliomyelitis, epidemic encephalitis, scarlet fever, meningitis, etc.), we are less successful at the present time. These latter can at present be eradicated only by personal hygiene applied to the individual, the safeguarding of one person against another.

The control of the contagious diseases transmitted by infectious droplets from the respiratory tract is made even more difficult by the existence in practically all of these diseases of so-called "germ-carriers," people who are apparently well but harbor and spread disease germs. This control of the diseased individual and germ carrier is the most difficult problem in the prevention of communicable disease.

It necessitates early recognition of all cases of contagious disease, discovery of germ-carriers and their proper treatment and isolation, isolation and quarantine of all cases, an efficient health organization, and education of the public in the fundamental principles of personal hygiene. In diseases like influenza, scarlet fever, measles, and epidemic encephalitis, where the germ is probably a filterable virus, the difficulties are even greater since we

have no laboratory methods at present for the diagnosis of the individual case.

Unless we can discover the germ and develop an effective preventive vaccination, we have only one line of attack in some of the recurring epidemic diseases like influenza, poliomyelitis, and epidemic encephalitis. This is the eradication of the endemic foci in various parts of the world. Such work could be accomplished only by some international organization such as the League of Red Cross Societies. The task will be a very difficult one, much more so than the eradication of malaria and yellow fever by mosquito destruction, or of typhoid, cholera and dysentery by water purification and vaccination.

With the conquest of communicable diseases by the application of our knowledge of bacteriology, immunology, and sanitary engineering, the average duration of life has been greatly lengthened in the last half century. The result has been that more people reach middle life, and consequently more cases of cancer, and cardiac, vascular and renal disease occur. Formerly only the highly resistant or physically fit were the survivors. Now, with our developments in preventive and curative medicine, many weaker individuals also survive. Perhaps this is why the average expectation of life at ages beyond sixty is not so high as it was hundreds of years ago; for inherited constitution fundamentally and primarily determines how long an individual will live. (Pearl).

At any rate the chronic diseases of the latter half of life, cancer, nephritis, organic heart disease, are increasing in most civilized countries and becoming the most important problems in preventive medicine. As we have at present little definite knowledge of their causes, it may be of value to briefly review the status of our views regarding these diseases, and to suggest ways of reducing the great mortality caused by them. Not only do we lack knowledge regarding their cause, but we do not even know what part heredity plays in their production. Is it not possible that inherited diathesis is an important factor in predisposing to these degenerative and neoplastic diseases? A knowledge of the hereditary and constitutional factors determining death from various diseases might be of great value. The problem is one in biology. In this connection it is interesting to note that Dr. Pearl has found from his statistical studies on influenza that the influenza epidemic mortality was closely correlated with the three great causes of

death, tuberculosis, diseases of the heart and diseases of the kidney. The severe epidemic killed chiefly those subject to these constitutional diseases which are concerned with functional breakdown of the three fundamental organ systems of the body. In what other acute diseases is there such a relationship? We cannot answer at the present time.

If the existence of constitutional disease predisposes to acute infections with a mortality higher than among the physically fit, must we not give more attention to the findings of the Provost Marshal General's office on the physical examination of several millions of men in the prime of life? Twenty-nine and fifty-nine hundredths per cent were found disqualified for military service by local boards, and an additional 8 per cent were rejected on re-examination by camp surgeons. Thus, 37 per cent of our young men were unfit for military duty by reason of physical and mental defects. What must be the percentage in the higher age groups? Of the defects which unfitted over one third of all the men examined, 88 per cent can be classified under six heads:

Diseases of bones and joints.....	26	percent
Special senses	15	percent
Cardio vascular	13	percent
Nervous and mental	10	percent
Tuberculosis	9½	percent
Defective physical development	8	percent

Much of this physical disability begins in early life when it is preventable. Over 80 per cent of the school children examined in New York City had major or minor illnesses or defects, many curable. They were decayed teeth, enlarged tonsils and adenoids, enlarged lymph glands, errors or refraction, middle ear disease, tuberculosis, etc. Are not many of these focal infections from which germs are carried to various organs and tissues causing most cases of organic heart disease, nephritis, arteriosclerosis, generalized tuberculosis? The recent surveys made at Framingham, Mass., indicate that 70 per cent or more of any typical group of people needs medical or dental advice or treatment for serious and minor ailments. The cheapness of human life is evidenced by the fact that there are over 500,000 deaths annually from communicable diseases, over 80,000 deaths from accidents, and over 5,000,000 sick.

The principal causes of death in the Registration Area of the United States in 1916, before the influenza epidemic and the war, were:

Heart disease	114,000
Tuberculosis	101,000
Pneumonia	98,000
Bright's disease	75,000
Cancer	58,000

As this area included only 70 per cent of the total population of the United States, and only 44 per cent of the total land area of the country, the deaths from the above causes for the entire country were approximately:

Heart disease	145,000
Tuberculosis	130,000
Pneumonia	125,000
Bright's disease	100,000
Cancer	80,000

Let us consider each of these unsolved problems of medicine, calling attention chiefly to what can be done at present to reduce their mortality.

CANCER

While 77,000 American soldiers gave their lives for their country during the two years of our participation in the Great War, about 180,000 people died of cancer in the United States. Few people realize the great toll of life taken by this disease. Cancer causes at present one out of every ten deaths in people past the age of 40. It is responsible for one in every eight deaths in women, and one in every thirteen in men above that age. More people over 40 are killed by cancer than by tuberculosis or pneumonia. About 95 per cent of deaths from cancer occur in people above 35. Between the ages of 35 and 45 three times as many women as men die of cancer. It is estimated that in 1920 the cancer mortality in the United States was close to 100,000.

What a small percentage of cases of surgically curable cancer is detected in the early stages! Cancer can be cured in a high

percentage of cases when seen early, for it is then a local disease. The average patient waits about twelve months before consulting a physician or surgeon. Unfortunately cancer is often not accompanied by pain, hence neglected until it has become inoperable.

Of the 90,000 deaths from cancer occurring annually we find the organs affected as follows:

Stomach and liver	35,000
Female generative organs	13,000
Female breast	8,500
Mouth and tongue	3,500
Large intestine and peritoneum.....	12,000
Skin	3,500
Other organs and parts	14,500

The exciting cause of cancer is at present unknown. We may look upon it as an abnormality of growth, a condition in which certain cells of the body multiply unchecked and usually serve no useful function. Perhaps certain hereditary factors cause an increased sensitiveness to mechanical and chemical stimuli in certain organs and tissues of the body. There can be no doubt that mechanical and chemical irritations play an important role in the causation of cancer. Perhaps the chemical stimuli are products of cell necrosis which, under certain local conditions influenced by heredity, internal secretions and abnormalities in early embryonic development, cause the functional energies of the cell to be transformed into growth energy. Similar growth can also be produced by chemical agents such as aniline dyes, coal tar derivatives, also paraffin, x-ray, burns, chronic inflammations. These facts suggest that there are probably many exciting influences which stimulate the cell proliferation. In certain sarcomas of lower animals a filterable virus has been obtained. In plant cancer a bacillus has been found. But in human neoplasms no micro-organism has thus far been shown to cause the disease. Given then an increased sensitiveness to growth stimuli, these chemical and mechanical agents acting for a sufficient length of time will cause neoplastic growth.

It is obvious from this brief discussion of the etiology of cancer that our only hope today is early recognition of cancer and pre-cancerous conditions, with proper surgical and radium treatment. This can be done only by education of the public regarding the

early signs of cancer and the necessity of prompt and efficient treatment. Here the physician, the health officer and the nurse have an obligation to the public. They can receive aid from the National and State Societies for the Control of Cancer. The surgeon must make use of the trained pathologist and co-operate with him in the diagnosis of his cases. The physician must recognize the cases in the pre-cancerous stage, or early stage of malignancy, or benignancy. The public health nurse is best able to advise women regarding the early symptoms and proper treatment of hard lumps in the breast, disease of the nipple, menstrual disturbances, etc.

TUBERCULOSIS

There are over 1,000,000 cases of active tuberculosis in the United States, with perhaps another million of inactive or quiescent cases. In other words, about one per cent of the population of this country is suffering with the great white plague. About 130,000 die annually of this disease. This figure represents one-tenth of all deaths from all causes, and about 30 per cent of preventable deaths. The discovery of the fact that 95 per cent of adults are infected with the germs of tuberculosis, and that at least 60 per cent of children have been infected at the age of ten makes the situation more hopeful than it seems. In other words, about 93 per cent of the adult population become infected without developing active disease. They develop a degree of immunity which protects them against subsequent infection, unless that infection be massive or oft-repeated.

On the other hand, mild infection by way of the digestive tract, or, less often, the respiratory tract, in childhood, may lie dormant for years only to produce active tuberculosis through lowered resistance caused by dietary deficiencies and such diseases as diabetes, measles, influenza, typhoid, pneumonia, etc. Massive infection in infancy or childhood is usually followed by an acute form of the disease with a high death rate, especially during the first few years of life, when no immunity exists. The same is true of races of human beings, which have not previously suffered infection. In other words, massive infection, or frequent re-infection in the non-infected causes an acute form of tuberculosis. In the previously infected (occult, or benign or quiescent infec-

tion) such infection may produce a chronic, resistant form of tuberculosis, the type most often seen in adults.

It is clear that to solve the tuberculosis problem we must discover (1) an effective vaccination in childhood which will protect against subsequent infection, or (2) a chemotherapeutic agent or specific drug that will cure the disease. With reference to vaccination the recent work of Shiga is very promising. He is using in children a vaccine of tubercle bacillus which is readily absorbed and gives only slight reaction. It is an emulsion of a tryptoflavinfast strain of human bacillus, avirulent for the guinea-pig in doses of 1 mgr. sensitized by immune serum, and with the addition of a filtrate of the broth of an erythrosin-fast culture. Very good results have been reported with this method of vaccination. Data on its prophylactic value can be obtained only after long observation of large numbers of vaccinated children. The vaccine of Calmette may also prove to be of considerable value. The experiments on cattle have been very successful. Plans are now being made to carry on similar experiments on anthropoid apes.

No chemical substance has yet been found which can be said to be a specific cure for tuberculosis. Such an agent must not only be tuberculocidal, but it must be able to penetrate the avascular tubercle and the waxy capsule of the bacillus and retain its activity in the body. It must therefore possess a selective toxicity toward the tubercle bacillus. Arsenic compounds, various aniline dyes, iodine compounds, and heavy metals have been tried. Some promising results have been obtained with a few chemical compounds and the future may reveal some specific drug. The chemotherapy of tuberculosis is an unlimited field for research, with the thousands of chemical agents yet to be tried.

For the present we must be satisfied with the reduction of active tuberculosis by (1) increasing body resistance and (2) avoiding massive or oft-repeated infection.

Tuberculosis is largely a social and economic problem, one which concerns the entire community, and can be solved by united efforts. Periodic physical examinations, strict supervision of children, proper diet, sanitary homes, pasturization of milk and tuberculin-testing of cows, free dispensary, and clinic treatment, and sanitarium treatment of advanced cases are some of the ways in which the disease must be reduced. The behavior of man is more important than that of the bacillus. The active case is a

menace to the community and often infects all of his associates before his disease is recognized. He may expectorate as many as a billion germs in twenty-four hours. Unlike other infectious diseases there is often no definite incubation period, and the early symptoms are vague. Expert examination is necessary for such early diagnosis. The person with positive sputum is an advanced case, often incurable, and the chief source of spread of the disease.

ARTERIOSCLEROSIS AND CARDIOVASCULAR DISEASE

Arteriolosis and cardiovascular disease, although closely related, are by no means identical. We find severe chronic lesion in the arteries without the usual symptoms of cardiovascular disease, and there are cases of cardiovascular disease practically free from arterial lesions. In many instances both occur simultaneously in varying combination. (Ophuls).

The ultimate cause of both these conditions has been sought in certain chronic intoxications and infectious diseases, especially rheumatic infections, typhoid, diphtheria, tuberculosis and syphilis. Dr. Ophuls has recently thrown much light on this subject by a thorough clinical and anatomic study of five hundred complete necropsies. He determined preceding infection by clinical history and careful examination for old inflammatory lesions in tonsils, heart valves, and other known foci of chronic infection.

In the cases in which all history or signs of previous infections were absent chronic arterial disease was almost entirely absent, but appeared early and frequently in the group with infections. Only certain infections seemed important, the chronic rheumatic (septic) conditions. Not only did the septic group include practically all cases of chronic arterial disease, but also all cases of hypertension and of nephritis in which there was sufficient history.

The arterial injuries usually begin in early life and progress pulmonary tuberculosis and syphilis were rarely related to arteriosclerosis and associated conditions, unless a chronic rheumatic condition was also present. This statement does not apply to aortic or cerebral arterial disease. Arteriosclerosis and hyper-

severe functional derangement of the cardiovascular system, at other times marked anatomic lesions, or both may co-exist.

Both are the result of the action of toxic bacterial substances which may at times attack the arteries, at other times the kidneys, or both. The arterial disease is not the cause of the nephritis nor the nephritis of the arterial disease. We find, then a series of cases: first, those of serious arterial involvement and little renal disease; then intermediate cases with marked involvement of arteries and kidneys; and those with severe nephritis and little arterial disease.

If these observations of Ophuls be correct, do we not have further evidence of the dangers from focal infections of teeth, tonsils, adenoids, middle ear, appendix; etc., so well emphasized by Billings and his colleagues several years ago? Are not most of our cardiovascular-renal diseases systemic manifestations of a pre-existing focus of streptococcus or other infection which develops in early life, and should be found and removed in childhood if possible? Perhaps a hereditary weakness of the cardiovascular-renal system makes some individuals more susceptible than others to the streptococcus, or some toxic substance, as yet undiscovered, which is the cause of nephritis and cardiovascular disease.

NEPHRITIS

Time will not permit me to discuss at length the various views regarding the etiology of the nephritides. I wish only to call attention to the rapidly developing view of the infectious nature of most of these types of degenerative, inflammatory and atherosclerotic renal disease. Careful studies of large groups of human cases indicate the importance of a focal infection, usually streptococcus, as the cause of the disease. In childhood nephritis usually follows scarlet fever, tonsillitis, erysipelas, endocarditis, rheumatic fever or chorea, in all of which the streptococcus undoubtedly plays the most important part. These are not the only causes, however. The nephritis may present itself months or years after a focal infection when the focus may no longer be present, and when if present its removal may be of slight value. We have already called attention to the probable independence of the cardiovascular lesions except for their common etiology.

The removal of recognized foci of infection as early as possible

prompt and efficient treatment of all acute infectious fevers (especially those accompanied by streptococcus infection), and dietary restrictions to decrease the amount of renal work and afford rest and opportunity for repair will do much to prevent renal disease. The preventive treatment of chronic nephritis is at present undeveloped because of our lack of knowledge of the etiology and factors influencing the progressive development of renal lesions. Here also removal of foci of infection during early life may prove to be the most effective preventive measure. After the foci have existed for some time even removal may fail to stay the progress of the disease.

PNEUMONIA

Pneumonia kills about 100,000 people annually in the United States. In the four months of the influenza epidemic (September to December, 1918) 500,000 people died in this country from pneumonia and influenza. The disease is usually caused by the pneumococcus, types 1, 2, 3, or 4. These can be differentiated by agglutination. This differentiation of types by obtaining the organism from the sputum is now of greater importance in the epidemiology as well as treatment, and possibly in prevention.

For type I pneumonia we have a specific immune serum which if administered in proper dosage early in the disease will cure most cases. Unfortunately we have no effective serum for the other types. With the exception of the use of type I serum the treatment is still largely symptomatic. Foreign protein therapy may be of value in certain cases, but must be used with caution.

In pneumonia prevention the mixed pneumococcus vaccine has already been shown to be of decided value. The work of Lister in South Africa and of several American physicians in this country has demonstrated its value in prevention in a certain per centage of those vaccinated. The value of influenza vaccines was no doubt due to their pneumococcus content.

The work of Blake and Cecil on experimental production of pneumonia in monkeys by intra-tracheal injection of organisms has greatly increased our knowledge of the pathology and modes of infection in this disease. The necessity of isolation of all cases and identification of carriers in prevention is of course well recognized.

DIABETES

Let us discuss briefly what can be done to prevent this disease of metabolism. It is estimated that there are 500,000 diabetics in the United States. Joslin has recently called attention to the relation of obesity to diabetes and found from his study of 1,000 diabetics that diabetes is largely the penalty of obesity. The overweight person is at least twice, and at some ages forty times, as liable to the disease as the person of average weight. Maintenance of average weight will prevent more than half of all the cases of diabetes in this country. Education by the medical profession along this line should be carried on vigorously. Cases that exist should be diagnosed as early as possible. This can be done by routine urinalysis. Early dietetic treatment is necessary to reduce the mortality from this disease and its sequelae.

We shall not be able to consider at this time the other metabolic diseases, or the dietary deficiency diseases, such as those due to deficiency of vitamins, etc.

SUMMARY AND CONCLUSIONS

We have seen that whereas the infectious diseases transmitted by insects, the water-borne diseases, and certain diseases for which we possess methods of specific immunization have been conquered, we are still unable to control the high mortality from degenerative diseases of the heart, blood vessels and kidney, cancer, pneumonia and other acute respiratory infections and tuberculosis.

In the cardiac, vascular, and renal diseases chronic septic (rheumatic) processes seem to play a most important part. They can no doubt be greatly reduced by early removal of focal infections.

In cancer, the cause of which is still unknown, we must depend upon education of the public, removal of precancerous conditions, upon surgical treatment, and the use of radium in selected cases.

In pneumonia and other acute respiratory infections, control of the individual patient and search for carriers with proper isolation and treatment offer us at best little hope in reducing the high mortality from these diseases. Perhaps vaccination will be the solution of the problem, as favorable results have already been obtained in pneumonia.

In tuberculosis, protection against massive or oft-repeated infection, especially during infancy and childhood, is most important. The environment of children must be made safe from tuberculosis infection. Mild infection in early life seems to confer a distinct immunity to subsequent disease. But inactive infection may become active disease unless a high body resistance is maintained at all times. The ubiquity of tuberculosis infection with only one percent of active cases in the population, indicates a high resistance to ordinary infection. Perhaps a vaccination will be discovered which will increase immunity. The work of Shiga and Calmette is very promising along this line. A chemical substance which will cure the disease may some day be found.

Lastly, better medical service rendered to the public through the establishment of fully equipped health centers in every community and available to the family physician for the diagnosis and treatment of disease, and periodic physical examinations; the organization of group medical clinics in larger centers of population for more expert diagnosis and treatment; further development of federal and state forces in disease prevention; and the promotion of scientific research and investigation will do much toward solving these problems in the future.

Modern medicine is becoming more and more a social service concerned with the prevention of disease, prolongation and betterment of life, improvement of physical health and efficiency through organized community efforts. The physician must uphold his reputation as the leader in this work. He can do this only by constantly acquiring knowledge. He must have the spirit of scientific investigation.

Let us adopt as our motto: "Every ill that can be relieved shall be removed."

The wisdom of Harvey, Leeuwenhoek, Jenner, Behring, Pasteur, Koch, Reed, Ross, Ehrlich, Wright, Rontgen, and many others has secured for us a greater measure of health and longer term of life. Let us do as well for the next generation.

Let us live for the present and the future.

"Not myself, but the truth that in life I have spoken,
Not myself but the seed that in life I have sown,
Shall pass into ages—all about me forgotten
Save the truth I have spoken, the things I have done."

SOME UNSOLVED PROBLEMS IN PHYSICS

C. W. Waggoner, Professor of Physics,

West Virginia University, Morgantown, W. Va.

One is inclined to say, if he is at all familiar with the developments in physics even in the past five years, that all the problems in physics are still unsolved. A great physicist once ventured the remark that all the great phenomena had been uncovered and that the research of the next century would in all probability be a study of the variations in the seventh decimal place of the constants that had been determined. Soon after that statement was published came the great discovery of X-rays. Chemists had been content to consider that the atom was the smallest single particle and chemical laws were built around this assumption. No small war was waged over the proof of the existence and purpose of the atom, and yet today even our most elementary text-books of physics and chemistry teach the interesting properties of the electron—a particle whose mass is presumed to be only about one two-thousandth that of the lightest of the chemists' atoms. The amazing popularity of the radio broadcasting program of today has brought this little fellow, the electron, into such prominence that the term is a household word. It seems safe to say that the development of the study of the electron and its properties is the greatest discovery of the last decade.

Notwithstanding the mass of data that is hourly being garnered by the researchers in this branch of science there remains a host of unsolved problems connected with this one interesting discovery. It is futile to even attempt to discuss the field of unsolved problems in connection with the study of the electron theory, for it touches all lines of human activity and any such attempt in a short space would result in merely a catalogue of some of the problems that have come to the writer's attention.

Historically, the oldest unsolved problem in physics is of course the question of the constitutionality of matter. The chemists had given the atom as the final division of matter but aside from postulating some of its chemical properties gave us no clue as to its ultimate constitution. It seems trite to say here that the modern war among physicists is over the atomic theory of matter. Thompson's atom with its positive charged nucleus

and its simple negatively charged electron revolving about the nucleus, very much as the moons of Jupiter revolve about the parent planet, was the first shot fired in this great war. This theory in its simplest form soon had its day and as the great mental guns were turned upon this theory it was discovered that it failed to explain many of the phenomena that had been known to man for many years. Researches in X-rays, thermionic currents, spectral lines, magnetism, and many other fields clearly showed that this simple hypothesis would not serve the ever growing data. Modifications of this theory have come and gone, each adding new light perhaps, but none giving the answer to the problem. The present, much talked of Bohr theory was derived in a most unorthodox fashion. The author of this present theory seems to have forgotten the creeds and tenets of his youthful physics and boldly invented physical laws as they seem to be needed. Strangely enough this mental picture of the atom does serve to explain some very intricate and complicated phenomena but it is now on the firing line. The big guns are being trained upon this theory and only time will tell if it is able to cope with the growing mass of experimental data.

Closely allied with the problem of the structure of the atom is the problem of gravitation and the theories of relativity. The public has evinced much interest in the relativity war. Einstein and his mathematical theory of relativity attracted the lay mind. The fact that it seemed to contradict the laws of classical mechanics put it on the firing line and a merry war is, or has been, waged over this interesting mathematical physical problem. There are those who find it hard to believe that a yard stick is actually shorter if it happens to be moving with a high velocity along a line thru its major axis than it is when it is quiet. There are unfortunately those who seem to doubt the accuracy of the only experimental evidence ever advanced as a proof of the theory; and so we may expect that unless some more definite proof is adduced to justify it, this theory of gravitation will soon go the way of Newton's theory of light.

One cannot but be struck with the ease with which the lay mind grasps these theories. The most complete and in many ways illuminating discussion the writer has ever heard of the Einstein theory of relativity was delivered by two Men's Ready-to-Wear salesmen on a Pullman train. Indeed the zest for

newer discoveries on the part of the great American public is and should be an inspiration to the plodding investigator.

One of the great outstanding problems in physics of interest to the general public as well as to scientific men everywhere is the use and control of intra-atomic energy. It has been shown that matter which has been disintegrated by the use of Radium and radio-active processes sets free some 250,000 times as much energy as would be set free by the combustion of the same amount of matter. How can we therefore set free these great forces that tie atoms to atoms and make use of the enormous amount of energy thus liberated?

Turning to what seems to be a much simpler problem we are confronted with great difficulty in storing up for some useful purpose the energy sent to our Earth from the Sun. It is estimated that the radiant energy from the Sun to our Earth may be something of the order of seven thousand horse-power per acre. Growing plants seem to have processes for absorbing and utilizing this energy and yet no practical process has ever yet been devised for bottling up the sunshine of our summer months and turning it loose again in the middle of the winter. This problem has its important economic aspect even to those of us in the great fuel State of West Virginia.

Problems confront us on every hand. The plants not only convert radiant energy from the Sun for their use but are able by some mysterious hydraulic process to carry their liquid foods from the ground to the tops of the highest trees. Where does this energy come from? Botanists have taken the laws of capillarity and surface tension from physics and tried to find the explanation but it is still being sought. In this connection it seems, from a discussion now being carried on in a well known journal of science, that we have not as yet found out what really happens when a field is harrowed. The farmer may say that it facilitates the operation of the drill for planting, but scientific study shows that this process is also one in which capillarity, surface tension and evaporation are so interwoven as to make the answer anything but simple.

Ben Franklin, America's first Physicist took his life in his hand with no adequate protection as to life insurance and discovered that the lightning flashes were electrical in their origin, but notwithstanding the many admirable protective devices which modern high tension power of transmission engineers have invented, the

exact nature of the lightning disturbance is still unsolved. Build and invent as we may, this strange force, because we do not know all of the laws governing its action, still is a great menace to the successful and continuous operation of long distance power transmission lines.

Lightning in some form, or "static" in the parlance of the amateur radio operator, is one of the most troublesome sources of interference in the operation of radio communication systems. In this instance the art is as yet all too new to have formed any very definite theory or hypothesis as to the origin or operation of this electrical disturbance.

When one returns to the radio communication art for the unsolved problems of this branch of physics each phrase becomes a question. Why should the radio wave follow the curvature of the Earth? Why should it not be possible to signal to Mars or to any other planet? What part does the conductivity of the earth play in the transmission of signals? What form of antennae is the most efficient? Have we reached the limit of our power to transmit signals over the surface of the earth? May we yet expect to be able to "tap the air" and provide our homes with light and heat from a station located in Java? In speaking with one of the best informed radio engineers in our country a few days ago the writer was told that we have at present about reached our limit in the matter of sending large electric currents in the antennae and that we must turn our attention next to more efficient methods for receiving and detecting the radio currents.

The older generation was taught that that mysterious thing called the ether, or aether, was responsible for the generation and propagation of the electric waves. It filled all space and that electricity was nothing more than some sort of vortex smoke-rings of this indestructible material, and yet science has never been able to objectively prove the existence of this mythical ether. Endowing it with the necessary attributes to explain some phenomenon in light we are surprised to find that such an ether should of necessity have the elastic properties of the most rigid steel that the world has ever developed. Yet the simple experimental fact that we are able to move about in such a world of rigid ether seems to raise a question as to the assumption or to the mathematical form of solution. Action thru a distance seems to require such an assumption and yet its existence cannot be proved.

The motion of such an ether with reference to the motion of our planet was the most promising point of attack and yet no satisfactory evidence has ever been produced that there is an ether drift. Einstein's postulates seem to need no such invention but the evidence to date of the magnitude of the Einstein effect puts it in the class of the ether drift experiments. They have been tried and found wanting so the problem is ever before us.

Much more simple problems lie all about us in the broad field of physics and its applications. About ninety-seven per cent of all the energy we put into the ordinary incandescent electric light evidences itself as heat while the other three per cent is responsible for the short electric waves which we are accustomed to speak of as light. Nature has been able, in the fire-fly, to radiate out into space only about those waves that are important in light; yet we blunder along using only about three per cent of the total power we purchase for our lamps as effective in producing illumination.

One of the saddest wastes of the world from the standpoint of practical and applied physics is the steam boiler-engine combination on account of the relatively large demands for power of this kind. Roughly it may be said that if one were able to utilize all the heat energy in a pound of our best West Virginia coal he should be able to run a 4.6 horse-power engine for one hour on one pound of coal, whereas practically we are able with the average boiler-engine combination to operate a very much smaller engine on the same pound of coal—an engine of about 1.8 horse-power.

Again, nature stored up under our mountains a combustible gas having 1125 heat units per cubic foot, yet the best we have been able to accomplish by converting our fuel coal to a gaseous fuel is to obtain only about 152 units of heat per cubic foot. Great strides are now being made in an effort to build and operate the coal dust or explosion engine or to use finely divided coal particles as one would a gaseous fuel but here again there are many fundamental problems that must be settled before man may make use of these forces.

Every worker in science is of course impressed with the fact that we are absolutely sure of so few things. This is particularly true of a science like physics where discovery of phenomena goes on at such a rapid rate. The newest text-book as it comes from the press is out of date even though its author made his best efforts to keep in sight the newest discoveries and theories. Only

the scientific journals with their story of the passing events are worth while if one cares to be up to the minute on the solved and unsolved problems in any scientific line. It seems only trite to say here that only as our scientific libraries are liberally supplied with the journals of all languages and peoples will it be possible for any individual worker to add his bit to the increasing knowledge of the world or will he be able to impart to students, if he be a teacher, the best and the latest the world has to offer.

In closing, then, the writer would like to say as he began that all problems in physics for the most part are unsolved. And those of us who labor in this beaten path would not have it otherwise. The instinct in man to search for the hidden truths in all lines of human effort is God-given. The almost overpowering curiosity of the growing child with all its intense eagerness to search out the hidden causes evidences this driving spirit of research in man in its earliest and perhaps its crudest form. The world old problem of education is the problem of directing and nurturing that research spirit.

PLANT DISEASE PROBLEMS IN WEST VIRGINIA

By N. J. Giddings.

Professor of Plant Pathology, and Acting Dean, College of Agriculture, West Virginia University.

(Contribution from Department of Plant Pathology, West Virginia Agricultural Experiment Station, Morgantown.)

Plant pathology is one of the youngest of the agricultural sciences. It has developed largely from the field of botany, has secured many of the suggestions for its methods of study from medicine, and is now drawing more and more upon the basic sciences of chemistry and physics.

Sick plants are not a modern development. References to them are found in the Bible and some of the writers of ancient Greece speak of their ravages. Epidemics of plant disease have resulted in famine at various time in history. They have been a source of much speculation and mystery for the disastrous effects of diseases are easily seen but the causes are usually microscopic organisms. Man likes to place somewhere the blame for all his troubles, and in the case of plant diseases his accusing finger has been pointed at everything from the phases of the moon to the person who planted the seed.

Let us note some of the effects of the activities of plant parasites: In 1918 the Department of Plant Pathology began to keep particularly careful records as to the actual plant disease injury to some of our more important crops. Figures concerning wheat, corn, oats, apples, peaches, potatoes, and tomatoes are now available for 1918, 1919, and 1920, and show an average annual loss of \$7,000,000.00 for West Virginia. In other words, the plant diseases are taking about seven million dollars a year which should be going into the pockets of the farmers, orchardists, and gardeners growing the crops mentioned above. These figures are conservative, have been checked up from various angles, and include only the more important commercial crops.

Occasionally someone inquires as to why we hear so much more about plant diseases now than we used to. There are several reasons for this and some of them may well be mentioned. In the first place, there are more diseases affecting the plants of any given locality now than there were some years ago. We have imported diseases in shipments of fruit, grain, hay, vegetables, nur-

sery stock, and other things of this kind from all parts of the United States and from other countries. Even as we have been free and easy about immigration, we have also given little thought to the plants and seeds which we were taking into our community. Just as some of the unsuspected human immigrants have spread treason, crime, and disease in the human family, some of the plant immigrants have spread new and destructive diseases to our growing crops. At present we have begun to realize the need of more careful quarantine regulations for plains, animals, and humans, and the careful scrutiny of all importations of every living thing from man to microbe.

It should be noted that West Virginia is now being threatened with at least two comparatively new importations of plant diseases. One of these is the wheat nematode or eel worm disease and was presumably brought into Virginia or West Virginia from Europe. It is found in both states. The other is potato wart, which seems to have been taken into the coal mining regions of Pennsylvania and West Virginia in importations of potatoes from England. It is now found in Pennsylvania, West Virginia, and Maryland.

Another reason for the increased interest in plant diseases is the fact that farming is more of a specialized field than it used to be. Many men now devote practically all their time and attention to one crop, and large sections of the country are specializing in a certain variety. Such a state of affairs has many advantages from the commercial standpoint, and some wonderful opportunities from the viewpoint of the plant parasite. Any parasite which finds large, contiguous areas of a favorite host plant is "in clover", figuratively speaking.

A third reason why more is heard about plant diseases now is because they are being studied, and as new facts are learned their importance is becoming appreciated to a greater extent.

West Virginia has a wonderful flora, and it should have a wonderful fauna, but the plant life has been better able than the animal life to withstand the ruthless hand of careless man who merely sought to fill his own pockets at the expense of our mountain forests, and streams. The same factors which favor the wide variety and distribution of our green plants have encouraged the development of an unusually abundant fungous flora and this includes an immense number of parasitic forms. Many diseases which are typically northern and others which are typically

southern are found within the borders of this State. Such diseases find some favorable locations where they are able to survive year after year and from which they can rapidly spread over a larger area whenever suitable conditions arise.

Some of our most important diseases at this time are the late blights of potato and tomato; the *Fusarium* wilts of potato, tomato, and cabbage; the tip burn of potatoes; the leaf spot of tomatoes; the black rot, rust, scab, root rot, and twig blight of apples; the wheat rust; the wheat scab; and the grain smuts.

Plant pathology involves fundamental questions in farm economics. One has the land prepared for a crop; fertilizes it; plants the seed; and, if disease does not destroy the seedling plant, gives it cultural attention throughout the growing season. Very few people would care to go to all this trouble and expense for the purpose of feeding a lot of parasitic fungi, yet such fungi take an astounding toll from every food crop raised in West Virginia. Some of us may feel that we are not much interested in Plant pathology, but plant parasites are keenly interested in our crops, and we may rest assured that any lack of interest on our part is paid for at an extremely high rate of interest, since sometimes as much as 100 per cent of the crop is taken by the fungi.

For some diseases the plant pathologists have already worked out very effective control measures, and it is up to everyone who wants good crops to learn what they are, and then to apply them. In the cases of many diseases a practical means of control has not yet been found, but for all plant diseases the pathologists are constantly endeavoring to discover better and cheaper control measures.

It is a well known fact that persistent and careful study of any parasitic disease will sooner or later reveal a weak point in its life relationship which can be successfully utilized for the effective, practical control of the parasite. One of the first things to be sought is how and where it exists during the dormant season. It often happens that the possible sources of infective material may be destroyed during the dormant period. In the case of wheat loose smut the fungus lives over inside the grain of wheat and it has been found possible to treat the grain with hot water at a temperature which destroys the parasite but without injury to the host.

It is important to know just what conditions favor or retard

the spread of disease, as we may be able to avoid such as would rapidly disseminate the parasite. Other points to be determined are the factors which favor or hinder infection of the host. Sometimes the host is susceptible only at certain stages of growth or under the influence of some change in its food relations. There is urgent need for a better knowledge of the fundamentals of fungous nutrition. The relationship of each parasite to acids and alkalis, different forms of nitrogenous material, starches, sugars, fats, and the like must be known. With such information the host relationship, can be readily determined, and the chemical attributes to be sought in a plant which should be resistant or immune to any specific disease can be easily ascertained. The physical structure of the plant must also be studied as this may have an important bearing upon its susceptibility or immunity.

This all means that we must study these problems carefully with our senses alert and our understanding clear; that we must experiment faithfully and persistently in the laboratory and in the field; that we must delve far into the unknown and make it known; and that we must have the co-operation of botany, entomology, horticulture, chemistry, and physics. Our object is real service, and our ambition is to take the subject of plant pathology from the land of mystery into the clear field of reason and fact, putting our information into such form that it may be readily available and useful to everyone interested in plant culture.

BULLETIN

of the

WEST VIRGINIA UNIVERSITY SCIENTIFIC ASSOCIATION

VOL II.
NO. I



April
1923

CONTENTS

	Page
List of Officers of the West Virginia University Scientific Association	2
Editorial Note	3
Program of the West Virginia Scientific Association	3
Bibliography, additional since Vol. 1, No. 1	5
Abstract of Scientific Articles published by Members of the Faculty since May, 1922	9
Absorption of Light by Mixed Solutions of Colored and Colorless Chlo- rides; By E. F. George	15
Notes on the Crocodilia of British Guiana; By A. M. Reese	21
The Enzymes of the Red Blood Corpuscles of the Mammal and the Amphibian; By Sobiesca Hall, U. O. Sanders and Withrow Morse.....	31
A Slide Rule Representation of Einstein's Restricted Theory of Rel- ativity; By Clarence N. Reynolds, Jr.	34

Published by the West Virginia University Scientific Society,
Morgantown, W. Va.

OFFICERS
of the
WEST VIRGINIA UNIVERSITY
SCIENTIFIC ASSOCIATION

PAST PRESIDENTS

A. R. Whitehill.....	1914-15
S. B. Brown.....	1915-16
F. E. Emory.....	1916-17
C. W. Waggoner.....	1917-18
B. H. Hite.....	1918-19
A. M. Reese.....	1919-20
Aaron Arkin.....	1920-21
N. J. Giddings.....	1921-22

OFFICERS FOR 1922-23

President.....	R. P. Davis
Vice-Pres.....	G. S. Dodds
Secretary.....	G. R. Bancroft
Treasurer.....	M. J. Dorsey
Program Committee	{ R. P. Davis N. J. Giddings F. E. Chidester G. R. Bancroft

EDITORIAL NOTE

At a meeting of the Scientific Association held the twenty-fourth day of November, 1922, the President of the Association was instructed to appoint an Editorial Committee to gather material for this year's Bulletin and to attend to its publication. The committee appointed consisted of Dr. N. J. Giddings, chairman, and Drs. F. E. Chidester, G. S. Dodds, Withrow Morse and John L. Tilton. This bulletin is the result of their efforts.

PROGRAM OF THE WEST VIRGINIA UNIVERSITY
SCIENTIFIC ASSOCIATION

The following papers were presented at the monthly meetings of the Scientific Society during the past year, by members of the University Scientific Faculty and by men not connected with the University.

November 4, 1921. Dr. Aaron Arkin, West Virginia University. Subject: "Some Unsolved Medical Problems." The paper discussed some of the larger problems which are before the Medical Profession at the present time, in the attempt to control disease.

December 2, 1921. Dr. L. R. Jones, Vice Chairman of the National Research Council and Head of the Department of Plant Pathology, University of Wisconsin. Subject: "The Art of Self Defense in Nature." The speaker illustrated certain important principles about plant diseases by an account of the work by which he had developed a strain of cabbage resistant to the fungus of 'cabbage sick' land. He spoke briefly of certain phases of the work of the National Research Council.

January 27, 1922. C. A. Jacobson, West Virginia University. Subjects: (1) "Alfalfa Saponin, a non-toxic foam-producing substance." This substance, he had isolated from alfalfa during work carried on in the state of Nevada. Such a substance would be of use in the preparation of soda fountain drinks. (2) "A New Calculating Machine, in the form of an Improved Slide Rule," designed and patented by the speaker.

March 3, 1922. Dr. W. J. Humphrey, Chief Physicist of the U. S. Weather Bureau. Subject: "Fogs and Clouds." The speaker described and illustrated with lantern slides the different types of clouds, and commented on their mode of formation and significance.

March 31, 1922. John L. Tilton, West Virginia University. Subject: "Recent Developments with Reference to the Great Ice Age in North America." The speaker described some recent investigations of glacial deposits, in which he had a part, illustrating the talk with lantern slides furnished by the University of Iowa.

April 28, 1922. H. M. Freeman, Westinghouse Manufacturing Company, Pittsburgh. Subject: "The Development of Radio Communication." The speaker traced the development of wireless communication from its beginning, calling attention to each important step. At the close

of the program the speaker gave a demonstration of the receipt of a radio broadcast concert from Pittsburgh, the first public demonstration of its kind in Morgantown.

May 31, 1922. Withrow Morse, West Virginia University. Subject: "A Mutually Protective Association—the Human Body." The speaker described certain chemical adjustments within the body, brought on as the result of natural processes.

October 27, 1922. Dr. Reinhardt Thiessen, Chemist and Microscopist of the Bureau of Mines, Pittsburgh. Subject: "The Constitution of Coal as Revealed by the Microscope." The speaker showed clearly the details of plant structure in coal, by lantern slides from photo-micrographs, and gave to the audience a new conception of the origin of this important fuel.

December 8, 1922. G. S. Dodds, West Virginia University. Subject: "The Stream-line form, as Applied by Animals." The speaker described the form of body that had been taken by various groups of animals for rapid movement through water or air, and illustrated in detail by nymphs of mayflies living in rapid streams.

February 7, 1923. Dr. James P. Porter, Ohio University, Athens, Ohio. Subject: "Intelligence Tests and Educational and Vocational Psychology." The speaker described various tests of intelligence, as applied to students and others, and pointed out how, by their wider use, many young people might be prevented from entering callings for which they have no natural fitness.

February 23, 1923. Dr. Elmer V. McCollum, Professor of Chemical Hygiene in the School of Hygiene and Public Health of the Johns Hopkins University. Subject: "The Relation of the Diet to the Physical Development." Dr. McCollum has conducted many and varied experiments in the study of nutrition of animals, and has made extensive contributions to the literature of the subject. He spoke concerning 'vitamines,' those obscure, but important constituents of foods, to the knowledge of which his investigations have made important contributions. His most recent work appeared last year under the title "The Newer Knowledge of Nutrition," published by the Macmillan Company, of New York.

BIBLIOGRAPHY

Papers published since Vol. 1, No. 1.

- * **BARNETT, GEORGE ROCKWELL.** Instructor in Chemistry.
B. S., Monmouth, 1918; M. S., 1922.
- BONAR, MARTIN LOXLEY.**
Member W. Va. Med. Assn.
Deterioration of Procain Solutions. Jour. Clin. Med., Current Number.
- BOOMSLITER, G. P.**
Are Hoisting Ropes too Light for Economy? Coal Mine Management. 2: 17, 1923.
- * **BRYAN, OLLIE CLISTON.** Asst. Soil Chemist.
B. S., Alabama Polytech., 1918; M. S., Wis., 1921; Ph. D., Wis., 1921.
Fellow, Soil Dept., Wis., 2 yrs.; Sigma Xi; Gamma Alpha; Phi Sigma. (Graduate honorary fraternities.)
- CHIDESTER, FLOYD EARL.**
Anopheles quadrimaculatus and Anopheles punctipennis in Salt Water. Science, N. S., 51: 244-5, 1920.
Studies on Fish Migration. I. The Behavior of Fundulus Heteroclitus on the Salt Marshes of New Jersey. Amer. Nat., 54: 551-58, 1920.
Studies on Fish Migration. II. The Influence of Salinity on the Dispersal of Fishes. Amer. Nat., 56: 373-80, 1922.
A Simple Method for Studying the Factors Influencing Fish Migration. Proc. Soc. Exp. Biol. and Med., 18: 175-77, 1921.
A Rabbit With Five Legs and Six Feet. Jour. Heredity, 12: 192, 1921.
- CORNELL, F. D.** Instructor in Farm Management.
B. S., Syracuse, 1919.
Joint Author, W. Va. Agr. Exp. Sta. Bull. 180.
- * **CURRENT, HOWARD WESLEY.** Assistant in Bact. and Path.
B. S., W. Va., 1922.
- DADISMAN, A. J.**
W. Va. Agr. Exp. Sta. Bull. 180.
- DAVIES, EARL C. H.**
Liesgang Rings. I. Silver Chromate in Gelatin, and Colloidal Gold in Silicic Acid. Jour. Amer. Chem. Soc. 44: 2698-704, 1922.
Liesgang Rings. II. Rhythmic Bands of Dyes on Filter Paper and Cloth by Evaporation. The Refractivity, Surface Tension, Conductivity, Viscosity, and Brownian Movement of Dye Solutions. Jour. Amer. Chem. Soc. 44: 2705-9, 1922.

* New members of faculty since May, 1922.

DODDS, G. S.

The Area of the Chorionic Villi in the Full Term Placenta. *Anat. Rec.*, 24: 287-94, 1922.

Mayflies from Colorado. Descriptions of New Species and Notes on Others. *Trans. Amer. Ent. Soc.*, 49: No. 1, 1923.

DORSEY, M. J.

The Set of Fruit in Apple Crosses. *Proc. Amer. Soc. Hort. Sci.*, 1921. P. 82.

Hardiness from the Horticultural Point of View. *Proc. Amer. Soc. Hort. Sci.*, 1921. P. 173.

• **FENTON, CLEMONT COLEMAN.** Instructor in Pathology.

A. B., Columbia, 1915; M. S., W. Va., 1922.

New York Univ., summer, 1920; Univ. Mich., summer, 1921; Columbia, summer, 1922.

• **FISK, IRA WILLIAM.** Professor of Electrical Engineering.

B. S., Illinois, 1909; M. S., Illinois, 1913; E. E., Illinois, 1914. Member, Am. Inst. Elect. Engrs.; Am. Elect. Railway Assoc.; Soc. for the Prom. Eng'g. Ed.; Sigma Xi, Eta Kappa Nu, (Semi-honorary for Electrical Engineers).

Member of Engineering Faculty, University of Illinois, 1909-1918; Consulting Engineer, Champaign-Urbana Water Company, 1917-1918; Professor of Electrical Engineering, Drexel Institute, Philadelphia, 1918-1919; Consulting Engineer, (Beeler organization), 1919-1921; General Manager Light and Power Department, Springfield, Illinois, 1921-1922.

Gas Engine Ignition. *Technograph*, XXX. I. W. Fisk and T. Kawamoto.

Notes on Electrically Operated Deep Well Pumps. *Technograph*, XXX. I. W. Fisk and P. S. Biegler.

Some Tests of Electrically Operated Deep Well Pumps, *Jour. Am. Water Works Assoc.*, XXXII.

Current and Voltage Relation in Two Phase Three Phase Transformation. *Technograph* XXXII. I. W. Fisk and P. S. Biegler.

Some Tests of Electrically Operated Deep Well Pumps. *Jour. Am. Water Works Assoc.*, April 1918. P. S. Biegler and I. W. Fisk.

War Time Operation of Motor Driven Deep Well Pumps. *Elect. World*, 1918. P. S. Biegler and I. W. Fisk.

GEORGE, E. F.

Member Pi Mu Epsilon (Honorary Mathematical Fraternity).

Absorption of Light by Inorganic Salts. Privately printed.

See abstract in *Chemical Abstracts*, 16: 3262, 1922.

Absorption of Light by Mixtures of Inorganic Salts. *W. Va. Sci. Bull.*, 2: No. 1, 1923.

• **HERZOG, VIRGIL ROSS.** Assistant in Pharmacology.

Ph. G., W. Va., 1922.

• **HOPWOOD, ARTHUR.** Assistant in Zoology.

B. S., W. Va., 1922.

• New members of faculty since May, 1922.

An interesting Case of *Cysticercus fasciolaris* Infecting the Brown Rat. *Parasitology*, 14: No. 1, 1922.
The Anatomy of a Two-headed Calf. *Anat. Rec.*, (In press).

JACOBSON, C. A.

A Reagent Bottle Siphon. *Jour. Indust. and Eng. Chem.*, 14: 731, 1922.
A Chemical Spelling Match. *Science*, N. S., Sept., 1922.

• **JOHN, BENJAMIN CLIFFORD.** Instructor in Anatomy.

M. D., Univ. Maryland, 1920.
Amer. Med. Assoc.; Rush Medical Club; W. Va. State Med. Assoc.

KUNST, FRANK B. Chief Chemist, W. Va. Dept Agr. and Asst. Chemist, W. Va. Agr. Exp. Sta.

B. A., W. Va., 1906.
Asst. Chem., W. Va. Exp. Sta., 1901; Asst. Chem., W. Va. Dept. Agr., 1917; Acting Chemist, W. Va. Exp. Sta., 1921.
Amer. Chem. Soc.; Assoc. Official Agr. Chemists; Assoc. Officials of Feed Control of the U. S.
Joint Author, W. Va. Exp. Sta. Bulls. 125, 132, 138, and of Inspection Bulls. 1, 2, 3, 4, and 5.
Joint Author, W. Va. Dept. Agr., Inspection Bulls. 36, 38, 46, 49, and of 1921 Inspection Report.

• **LEONIAN, LEON H.** Assistant Plant Pathologist, Exp. Sta. B. S., Kentucky, 1916; M. S., Michigan, 1917; Ph. D., Michigan, 1922.

A. A. A. S.; Botanical Society of America; American Phytopathological Society; Sigma Xi.
Assistant Research Horticulturist, South Carolina Station 1917-18; Assistant Professor of Biology and Plant Pathologist, New Mexico State College and Experiment Station, 1918-20.
Fusarium Wilt of Chile Pepper. *New Mexico Bulletin* (technical) 121, 1919.
Studies on the Valsa Apple Canker in New Mexico. *Phytopathology*, 11:236, 1921.
Stem and Fruit Blight of Peppers Caused by *Phytophthora capsici* sp. nov. *Phytopathology*, 12:401, 1922.
A study of Factors Promoting Pycnidia Formation in Some Sphaeropsidales. In press; will appear in *American Journal of Botany*.
The Physiology of Perithecia and Pycnidia Formation in *Valsa leucostoma*. In press; will appear in *Phytopathology*.

• **METZ, ROY D.** Assistant in Anatomy.

B. S., W. Va., 1922.

MORSE, WITHROW, Sobisca Hall, and S. O. Sanders.

The Enzymes of Red Blood Corpuscles. Abstract in *Jour. Biol. Chem.*, 55: xxvii, 1923. Also in *W. Va. Sci. Bull.*, 2: No. 1, 1923.
The Rise of Acidity in Autolysis. *Jour. Biol. Chem.*, 55: viii, 1923.

• New members of faculty since May, 1922.

* MURRAY, F. H. Instructor in Mathematics.

A. M., Harvard, 1917.

On Implicit Functions. Bull. Amer. Math. Soc., 27: 1920.

The Asymptotic Expansion of the Sturm-Tionville Functions. Ann. Math., 22: 1921.

A Classification of all the Polygons Having a Given Set of Vertices. Congres Intern. des Mathematisiens. Strassbourg, 1921.

On Periodic Orbits in the Problems of Three Bodies. Bull. Amer. Math. Soc., 1923.

On Certain Linear Differential Equations of the Second Order. Ann. Math., 1923.

Sur les Solutions Isosceles avec Axe de Symmetrie dans le Probleme des Trois Corps. Bull. Astronomique, 1922.

REESE, ALBERT M.

Unusual Animal Foods. Sci. Monthly, 45: 475.

Habits of the Tegu Lizard. Copela, Sept., 1922.

Osteology of the Tegu Lizard. Jour. Morph., (in press).

Structure and Development of the Intromittent Organ of the Crocodilla. Jour. Morph., (in press).

Environment of the Calman. Ecology, (in press).

Notes on the Crocodilla of British Guiana. W. Va. Sci. Bull., 2: No. 1, 1923.

REYNOLDS, C. N., Jr.

The Derivation of Formulae in the Mathematics of Investment. Amer. Math. Monthly, 29: No. 3, 1922.

A Slide Rule Representation of Einstein's Restricted Theory of Relativity. W. Va. Sci. Bull., 2: No. 1, 1923.

* SHAFFER, J. H. Asst. in Farm Economics, Exp. Sta.

B. S. in Agr., W. Va., 1921.

Amer. Farm Economics Association.

Joint Author, W. Va. Agr. Exp. Sta. Bull. 180.

SIMPSON, JOHN NATHAN.

Progress in Medical Education. W. Va Med. Jour., 17: 120, 1922.

SPRAY, ROBERT SPAULDING.

Acting Director, Dept. of Bact., Univ. Chicago, Fourth Quarter, 1922.

Penumonia in Sheep. Jour. Infec. Dis., 31: 10-21, 1922.

A Proteoclastic Streptococcus from Pneumonias in Sheep. Jour. Infec. Dis. (in press).

The Bacteria in Normal and Diseased Lungs of Swine. Jour. Infec. Dis., 31: 10, 1922.

* TAYLOR, LELAND H. Instructor in Zoology.

B. S., Mass. Agr. Coll., 1914; M. S., Harvard, 1920; Sc. D., 1922.

Deputy Nursery Inspector, Mass. State Dept. Agr., 1915-19; Asst. Director, Plant Pest Control, Mass., 1920-21.

A. A. A. S.; Phi Kappa Phi (Honorary agricultural fraternity); Entomol. Soc. Amer.; Boston Soc. Nat. Hist.;

* New members of faculty since May, 1922.

- Cambridge Entomol. Club; Amer. Assoc. Economic Entomol.
Thoracic Sclerites of Homoptera. Ann. Ent. Soc. Amer., 11: 225, 1918.
Vespa arctica Rohwer, a Parasite of Vespa diabolica De Sauss. Psyche, 28: 135, 1921.
Notes on the Biology of Certain Wasps of the Genus Ancistroceros. Psyche, 29: 48, 1922.

TILTON, JOHN L.

The Strata Near Stuart, Iowa. Bull. Geol. Soc. Amer., 33: No. 4, 1922.

* **WILSON, PAUL R.** Assistant in Physiological Chemistry and Physiology.

B. S., W. Va., 1922.

YORK, H. H. and Walter N. Snell.

Experiments in the Infection of Pinus strobus with Cronatium ribicola. Phytopathology, 12: 148, 1922.

* **ZIMMERMAN, E. E.** Assistant Professor of Physics.

A. B. Indiana, 1916; A. M., Indiana, 1921.

Inst. in Physics, Washington Univ., 1919-1922.

Phosphorescence Resulting from Excitation of Calcium Sulphide Screen. Washington Univ. Studies, July, 1922.

Abstracts of Scientific Articles Published by Members of the Faculty Since May, 1922.

BONAR, MARTIN LOXLEY and SOLLMANN, TORALD.

The effects of some new local anaesthetics (Para-amino-benzoyl-di-normal-butyl-amino-ethanol and propanol; and diethyl-amino-propyl-diphenyl-amino-carbinol). Jour. Pharmacol. and Exp. Therapeut., 18: 467, 1922.**

These artificially synthesized local anaesthetics were compared in pharmacological action with that of the well-known cocaine and procaine and it was found that the propanol compound as hydrochloride has a toxicity one-half that of cocaine and procaine, that it is directly applicable to mucous membranes, to sensory nerves or may be injected; that it may be used with adrenalin as vaso-constrictor without affecting the blood vessels unfavorably; that it is non-irritating. It is capable of producing local anaesthesia in doses one-half those of cocaine, one-tenth that of procaine and about that of holocaine to produce the same effect. The ethanol compound as hydrochloride is less effective and its toxicity is as high as the preceding compound and moreover it is more irritating. The carbinol compound is less effective as an anaesthetic and its toxicity

* New members of faculty since May, 1922.

** The experimental work was performed in the pharmacology department, Western Reserve University.

is equivalent to the others while it is much more irritating. The first one is now marketed as "Butyn" by the Abbott Laboratories, Chicago, having been accepted by the Council on Pharmacy and Chemistry of the American Medical Association.

BONAR, M. L.

Deterioration of Procain Solutions. Jour. Lab. and Clin. Med., (Current). 1923.

Studies made to determine the factors causing deterioration of solutions of procain led to the discovery that vegetable moulds were responsible. Sterilization of the solutions followed by precautions against inoculation from spores makes it possible to keep solutions of procain indefinitely.

CHIDESTER, F. E.

Studies on Fish Migration. II. The influence of salinity on the dispersal of fishes.

Amer. Nat. 56: 373-80. 1922.

Fundulus heteroclitus is able to discriminate toxic from non-toxic salts at a temperature and stream flow the same as the control. Variations in temperature or in stream flow profoundly influence the reactions and are more powerful factors in the behavior of the fish than presence or absence of salinity.

DADISMAN, A. J., J. H. SHAFFER, and F. D. CORNELL.

The Farm Tractor in Mason and Berkeley Counties.
W. Va. Agr. Exp. Station Bull. 180, 1922.

This twelve page bulletin gives data of value with reference to work done on and off the farm by tractors, cost of operating, depreciation, contrast between horse and power labor.

Summary includes a list of the advantages and disadvantages of tractors and a resume of the results of the investigation.

Copies may be secured by addressing the Director of the Agricultural Experiment Station, Henry G. Knight, Morgantown, West Virginia.

DODDS, G. S.

The Area of the Chorionic Villi in the Full-Term Placenta.
Anat. Rec. 24: 287-94.

An average human afterbirth was measured, and calculations made to determine the area of the surface exposed by the chorionic villi to the maternal blood. The method employed made use of the microscopic sections, first calculating the area of the portions of villi included in a section of known area and thickness, and from this, computing their total area for the placenta. The area thus determined is about seven square meters.

DODDS, G. S.

Mayflies from Colorado. Descriptions of New Species and Notes on Others.

Trans. Am. Ent. Soc. 49: No. 1.

The paper describes collections of Mayflies from the Rocky Mountain region of Colorado. Twenty-three species are listed, more than half of which are new to science and described here for the first time. Nearly all of the species are here described in both nymph and imago stages, the life history having been determined by rearing the nymphs in screen cages.

GARBER, R. J.

Inheritance and Yield with Particular Reference to Rust Resistance and Panicle Type in Oats.

Minn. Agr. Exp. Sta. Tech. Bull. 7: 1922.

The inheritance of resistance to stem rust *Puccinia graminis avenae* Erikss. and Henn. was studied in the F_1 , F_2 , and F_3 generations of two oat crosses and was found to depend on a single main factor difference. Yield of seed was reduced by susceptibility to stem rust. The relation between panicle type and yield of seed was not consistent. A preliminary study of the inheritance of pollen abortion was also made.

GARBER, R. J.

Origin of False Wild Oats.

Jour. of Heredity. 13: 40-48. 1922.

The origin of false wild oats was studied in three quite different varieties of cultivated oats, *Avena sativa* and *A. sativa orientalis*. Mutations rather than the results of natural crossing seemed to be the more logical explanation of these aberrant forms.

MORSE, WITHROW.

The Rise of Acidity in Autolysis.

Jour. Biol. Chem., 55: viii. 1923.

By means of the Van Slyke carbon dioxide combining power method, various tissues were studied immediately after death. It was found that the alkali reserve of these tissues was depleted to a great extent. This is correlated with the previous reports made by the writer on the rise of acidity where an almost explosive formation of acid was recorded for dying tissues. Fixed acids, like lactic, deplete the reserve.

REESE, A. M.

A Note on the Breeding Habits of Tegu.

Copeia, Sept. 1922, p. 69.

A description is given of the eggs of this large, South American lizard. The eggs were found in a large nest of termites, instead of being buried in the ground as is described by previous writers. The eggs have a leathery shell and average about 49mm. x 36mm. in size.

REESE, A. M.

Unusual Human Foods.

Sci. Monthly, May, 1922. p. 475.

Various animal foods, from Mollusca to Primates, that have actually been eaten by the writer are described.

SIMPSON, JOHN N.

Progress of Medical Education at West Virginia University
Since 1921.* 1922.

West Va. Med. Jour., 17: 121.

Forty-nine graduated in medicine from this institution June, 1922. Difficulties are experienced in placing men having lower averages. Since some of these men have to work for their living while in school, a student loan fund is desirable making it possible for these men to devote maximum time to their medical work. It costs the state \$240 per student in excess of the student fees to carry him through his two years. A four year course is advocated, especially owing to the high cost of tuition when the men go to other institutions and also because of the difficulty in obtaining places in the third and fourth year classes. The last two years should be given in connection with the first two years, near the State University and the experiences of other medical schools not in large centers, such as Michigan at Ann Arbor, Wisconsin at Madison, etc. warrant the belief that good work may be offered at Morgantown.

SPRAY, ROBB SPAULDING.

A Bacteriological Study of Pneumonias of Sheep.

Reported from the Dept. of Hygiene and Bacteriology,
Univ. of Chi. (Ms. in hands of editor Jour. Infect. Dis.)

A bacteriological study of two types of pneumonias in lambs and older sheep. About fifty cases in all have been studied.

In addition to the true *Pasteurella ovisepticum* which is to be expected from lungs of sheep, four other organisms were found in such numbers as to give some significance to their presence.

1. *Pasteurella ovisepticum*; 2. An organism very similar, but fermenting maltose and lactose slowly; 3. An organism similar to (number 2) but not fermenting lactose; 4. A Gram negative diplococcus of the *Micrococcus catarrhalis* type; 5. A Gram positive diplococcus with short-chain tendency.

The interesting features of this study are the isolation of two organisms which can scarcely be differentiated from the true *Past. ovisepticum* (numbers 2, 3), and the Gram positive coccus (numbers 5) which was found not only in cases of pneumonia, but also in cases of caseous lymphadenitis (Pseudo-tuberculosis), a disease ascribed solely to the action of the Preisz-Nocard bacillus.

Agglutination tests agreed with the results of the cultural identifying reactions. Pathogenicity tests indicated that all of the organisms were virulent in small doses for mice, guinea pigs and rabbits.

SPRAY, ROBB SPAULDING.

The bacteria in normal and diseased lungs of swine.
Jour. Infectious Diseases, 31: 10. 1922.

One hundred normal lungs of pigs and 314 pathological lungs of similar animals were studied and 3 significant organisms were isolated, namely,

* Read at the annual meeting of the W. Va. Medical Association, Huntington, May, 1922.

B. suisepitiosus, and organisms similar to *B. alkaligenes* and an inulin-fermenting streptococcus.

Normal Lungs:

<i>B. suisepitiosus</i>	found in	4%	of the specimens.
<i>B. alkaligenes</i>	" "	3%	" " "
Streptococcus	" "	12%	" " "

Pneumonic Lungs:

<i>B. suisepitiosus</i>	found in	44%	of the cases.
Streptococcus	" "	35%	" " "

Other organisms were naturally occasionally encountered, but not in significant numbers. It is pointed out that whereas the presence of *B. suisepitiosus* is commonly accepted as sufficient evidence as to its responsibility for pneumonia in swine, the frequent occurrence of the inulin-fermenting streptococcus in pure culture indicates an almost equal etiological importance, judged solely by the criterion of frequency of occurrence. This streptococcus seems to be a member of the Holman Strep. Mitis group (a-typical in regard to inulin fermentation). It is a diplococcus, ovoid, with short-chain tendency without capsule. On blood-agar, it is very pleomorphic. Growth is more typical in serum broth. On blood agar plates, colonies run about 0.5mm. in diameter, discrete, lacking the "nipple" characteristic of typical streptococcus colonies. Old colonies reach a diameter of 2mm. Agglutination tests indicate the presence of at least three agglutinative types, but the agglutination tests are incomplete.

TILTON, JOHN L.

Strata near Stuart, Iowa.

Bull. Geol. Soc. Am. 33: No. 4. 1922.

This paper remaps a portion of Central Iowa where Professor Tilton found that the strata had been misinterpreted because others had failed to recognize the presence of a fault through the region between those beds and extensive quarries that had frequently been visited by geologists from various parts of the country. The paper also has an economic bearing on the distribution of coal affected by the fault, and makes possible a proper interpretation of two deep wells.

TILTON, JOHN L.

Observations on Coal Swamps in Northern West Virginia where Permain Conditions Prevailed.

Abstract, Geol. Soc. Am. Dec. 29, 1922.

At the Christmas meeting of the Geological Society of America, Dr. Tilton presented an attempt to visualize conditions found in coal swamps in the area between the Monongahela and Ohio Rivers.

Observations in northern West Virginia the past two seasons emphasize the idea of extensive swamps, of mushy constituency beneath the surface, surface covering reed-like, the growing surface creeping out into bodies of water generally fresh, where freshwater limestone is in process of deposition. Low fernlike plants (*Cycadofilicales*) are crowding out from the shore, and distant trees (tree-ferns?) are rising from

the low upland. There is no large growth unless it be *Calamites* out upon the swamp at a distance from the shore. The large growths (tree-ferns) are here confined to the higher ground and to margins of the swamps. The unusual view of a carboniferous swamp is thus the one that fits here where Permian conditions prevail—not the view of a carboniferous swamp that is commonly pictured.

The paper will be published in full later, as investigation is still proceeding.

YORK, HARLAN H.

Experiments in the Infection of *Pinus strobus* with *Cronartium ribicola*.
Phytopathology, 12: 148. 1922.

This paper discusses the method whereby white pine can be infected artificially with the disease known as white pine blister, a disease that is threatening the white pine forests of the United States. Such a discovery is a first and necessary step toward the elimination, or at least the control, of the disease. The study is of economic value to West Virginia, where white pine forests may become infected if the disease is not checked. In this work Professor York was assisted by Walter H. Snell.

Professor York has been invited to go to Washington to instruct the foresters, who in turn will instruct the lumbermen concerning the disease.

ABSORPTION OF LIGHT BY MIXED SOLUTIONS OF COLORED AND COLORLESS CHLORIDES

By E. F. GEORGE

Associate Professor of Physics, West Virginia University

A full and complete knowledge of the mechanism of the absorption of light would lead to the solution of most of the problems which confront the physicist of today; for it is a question of atomic structure, and most if not all of the problems of modern physics have for their ultimate solution the unravelling of the mystery of the structure of the atom.

The theory has been proposed that the energy of electromagnetic radiation which constitutes light waves is dissipated in the form of polarization and conduction currents in material media. This explanation, though apparently sound, does not account for more than a small part of the observed effect. The absorption of light has generally been thought of as a resonance effect. The phenomena of resonance plays a prominent role in every branch of physics. The musician tunes his violin and the radio operator tunes his apparatus. Both of these are resonance effects and the theory of the two is exactly the same. In light we have many examples of this effect. The bright emission lines of a glowing metallic vapor are "reversed" and become dark absorption lines when the vapor is placed in the path of a more intense light which gives a continuous spectrum. Certain phenomena, it is true, are not easily explained by, and are apparently inconsistent with, the resonance theory, but lack of space forbids further discussion of that.

How can we explain the absorption of light on the general principle of resonance? Presumably the vibrating electron (or whatever the resonator may be) extracts from the incident radiation the energy of those waves whose frequency corresponds to its own and re-radiates it in all directions. But this is scattering and not absorption, which is defined as the conversion of radiant energy into heat. If this energy which is picked up by the electron is re-radiated in all directions, there must be one ray in the direction of the original beam. But, according to Planck,¹ in the re-radiated waves there is a lag in phase of 180 degrees and consequently destructive interference. There should also be a beam in the opposite direction. This would seem to account for the phenomenon of selective reflection.

According to the theory of Bohr and Sommerfeld² the atom contains a number of electrons revolving in elliptic orbits about a positive nucleus. The electron may shift from one orbit to another, radiating energy in definite quanta if the shift is inward, and absorbing energy if the shift is outward. An electron in motion is an electric current. If electrons are revolving in coplanar orbits about an atom, that atom

¹ Berlin Acad., Berlin, 1903-04.

² Sommerfeld, "Atombau" 3rd Edition.

should behave as an electromagnet and should attract or repel other atoms, depending on their orientation. It should also possess a certain moment of inertia and a certain angular momentum and should thus function as a gyroscope.³ We should, therefore, hardly expect rotation of the atom as a whole, but would expect that molecular impacts would be followed by precessional vibrations as when a gyroscope is struck a sharp blow. (It should be observed that in Bohr's newer theory⁴ the orbits are not coplanar). The various physical properties of the atom—number of electrons, electronic orbits, moment of inertia, and angular momentum—are different in different atoms, and in the same atom depend on the state of aggregation, chemical combination, pressure, ionization, etc. We may, therefore, expect the frequency of vibration, and consequently the absorption of light, to be different under different conditions.

According to Baly,⁵ when two atoms unite to form a molecule, the constituent atoms may retain their characteristic frequencies, but superimposed on these are frequencies which are characteristic of the molecule; these frequencies being the least common multiples of the atomic frequencies. His expression for the subsidiary frequencies associated with a given true molecular frequency is $M \pm nI \pm mA$ where M is the particular molecular frequency concerned, I is one of the intra-molecular frequencies, A stands for the atomic frequency, while m and n stand for the numbers 0, 1, 2, 3, 4, etc. The center of the band will be found by making $m=0$ and $n=0$.

According to Lambert's law, which holds for monochromatic light, there is an exponential relation between the intensity of transmitted light and the thickness of the absorbing medium. According to Beer's law the absorption of light by a fluid of definite thickness is directly proportional to the concentration. In other words, the absorption is directly proportional to the number of molecules of the colored substance in the path of the beam of light. Beer's law holds approximately in a large number of cases and fails completely in perhaps a larger number. And moreover, if to a solution of a colored salt, as ferric chloride, a solution of a colorless salt is added, a profound change in the absorption may take place. It is thus apparent that molecular forces are at play which modify the color of a solution. It is also clear that Bohr's principle⁶ of selection cannot exist unhindered in a solution because of neighboring molecules.

Jones⁷ has explained these changes in terms of his "Solvate Theory." I wish to venture an alternative explanation which seems more simple and perhaps clearer.

For reasons mentioned above, the absorption of light by a salt in the ionic state is no doubt quite different from what it is in the molecular state. Therefore, absorption is a function of the dissociation, and disso-

³ Kruger, (Annal der Physik, IV, 50, 346; ibid 51, 450, 1916.

⁴ Zeitschrift Physik, 9, p. 1, (1922).

⁵ E. C. C. Baly, Phil. Mag., 40, p. 1, 1920.

⁶ Sommerfeld, "Atombau."

⁷ Harry C. Jones, Nature of Solutions, 1917.

ciation is a function of the concentration. On this hypothesis it is easy to see why Beer's law does not hold. If to an aqueous solution of a colored salt, as copper chloride, in a definite state of dissociation, we add a certain amount of a colorless salt, as sodium chloride, keeping the concentration of the copper chloride constant, we would expect some of the copper ions to be driven back into the molecular state, because of the increase in concentration of the chlorine ions. This naturally follows from the law of mass action or from the principal of van't Hoff that molecules and ions in solution behave as gases and obey the gas laws.

The following piece of work was undertaken in the hope of obtaining experimental data bearing on the above theories. The apparatus consisted chiefly of a Hilger constant deviation spectrometer with a Nutting photometer box. The colored solution, in a glass cell one centimeter in thickness, was placed in the path of one of the beams of light while an exactly similar cell, containing distilled water, was placed in the path of the other beam. The intensities were then matched by rotation of the analysing Nicol.

MIXTURES OF COPPER CHLORIDE WITH OTHER CHLORIDES

WITH AMMONIUM CHLORIDE. The effect is shown graphically in plate 2-a. The abscissae represent wave-lengths in milli-microns, while the ordinate represents absorption of light in terms of the extinction coefficient. The dotted curve represents the absorption of the colored salt alone, while the full-line curve shows the absorption of the mixture. I have determined the mathematical equation of the curve, as shown in the graph, and found it to be exponential in form. The concentration of the copper chloride was .2742, that of the ammonium chloride 3.1. The mixture shows very great absorption in the violet, although the copper chloride is transparent in that region of the spectrum, and ammonium chloride is as transparent as water throughout the entire visible spectrum. There is decrease in the green and yellow and increase in the red.

WITH POTASSIUM CHLORIDE, plate 2-b. Concentration of potassium chloride 2.2. There is marked increase in absorption in the red. The equation of the curve is exponential in form.

WITH ZINC CHLORIDE AND CERIUM CHLORIDE, plates 2-d and 2-e. No very startling effects are observed, although there is some increase in the red.

MIXTURES OF FERRIC CHLORIDE WITH OTHER CHLORIDES

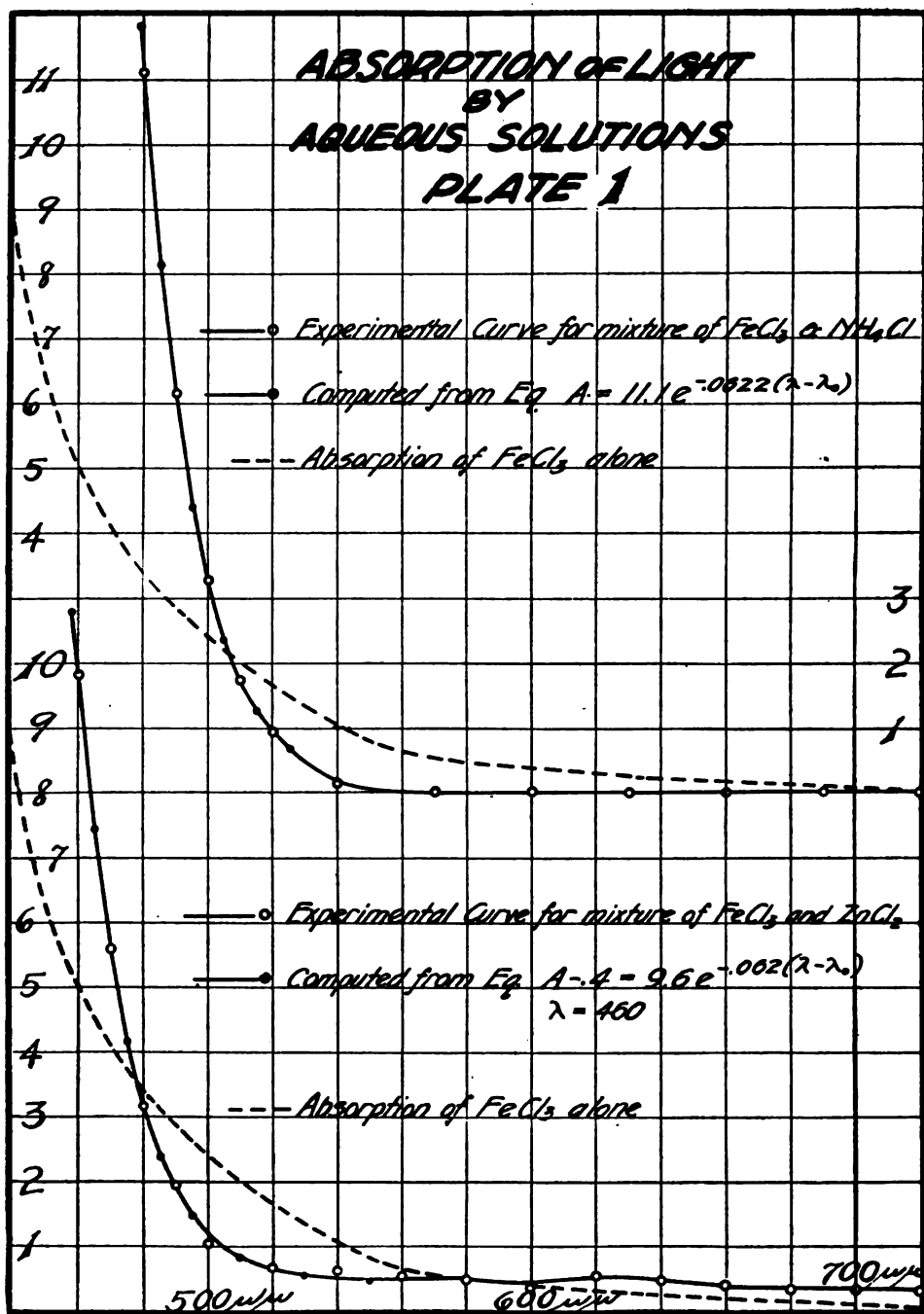
WITH AMMONIUM CHLORIDE, plate 1-a. Concentrations were: Fe Cl, .1560 and (NH)₄ Cl 2.8. There is tremendous increase in absorption in the violet and blue, with considerable decrease in the green. At wave-length 480 the increase is more than 200%. The curve is found to be exponential, as shown in graph.

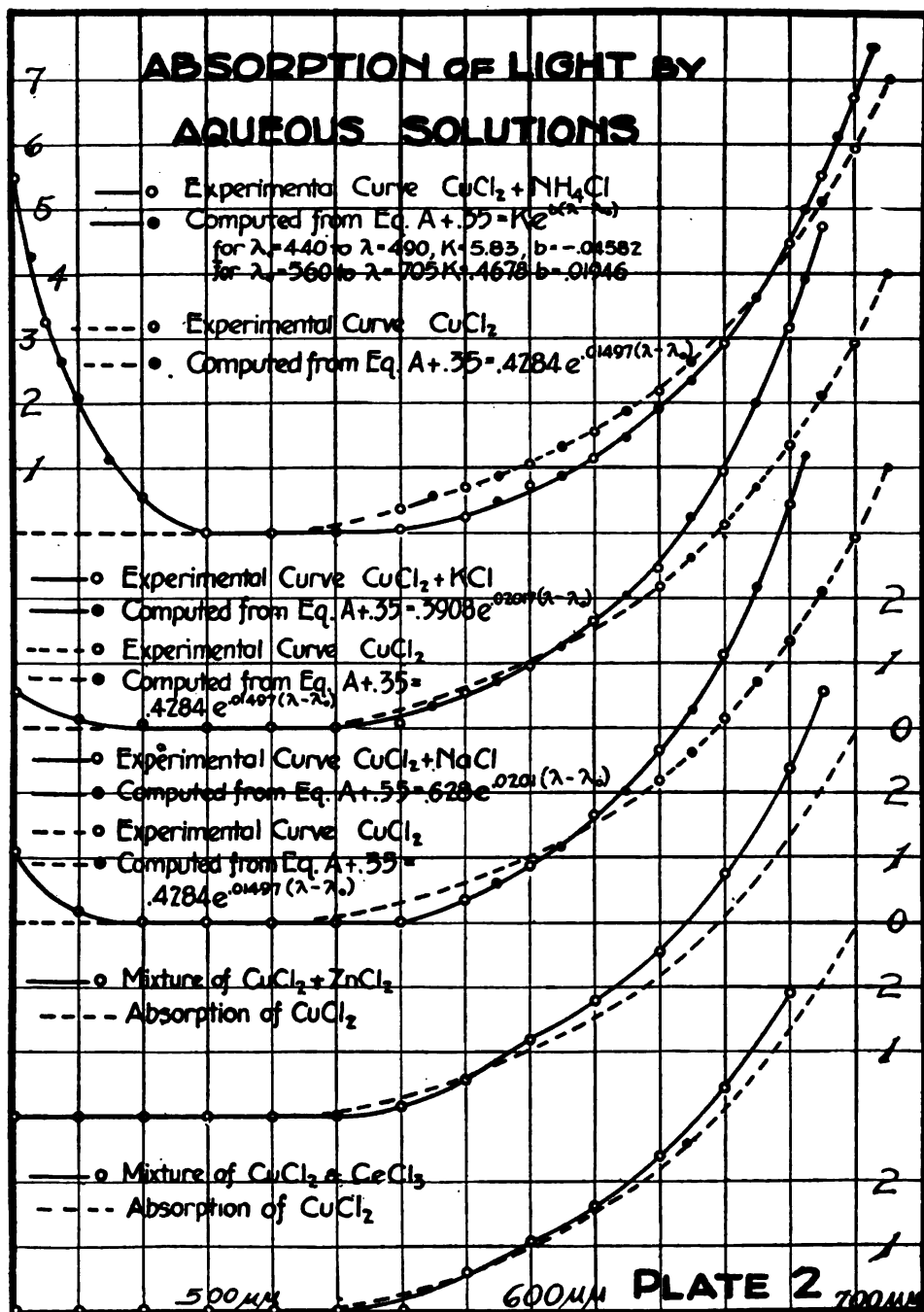
WITH ZINC CHLORIDE, plate 1-b. Concentration of zinc chloride 1.3. There is seen to be enormous increase in absorption in the violet and decrease in the green.

SUMMARY

The absorption of light by mixtures of the aqueous solutions of certain colored and colorless chlorides throughout the visible spectrum has been measured and the curves plotted. The absorption of the colored chlorides alone is plotted as a companion curve. The difference between the two shows the effects of the colorless salt. The mathematical equations of some of the curves have been determined and found to be exponential in form.

It has been shown in this series of experiments that such salts as ammonium chloride and potassium chloride which do not readily form hydrates are as effective in producing changes in absorption as those salts which do easily form hydrates. Jones' "Solvate Theory" is therefore, untenable. The writer has advanced the theory that the change in absorption is a function of the change in ionic concentration.





NOTES ON THE CROCODILIA OF BRITISH GUIANA

By A. M. REESE

Professor of Zoology, West Virginia University

NOTE:—A few years ago Professor Reese was in Florida under the auspices of the Elizabeth Thompson Science Fund investigating the habits of the Florida alligator. The results of that work were published in the reports of the Smithsonian Institution at Washington. Later the Carnegie Institution sent him to British Guiana to study there the habits of the alligator and the caiman. The caiman material which he collected is now here at the university, but will eventually be deposited in Baltimore.

EDITORIAL COMMITTEE.

According to Beebe's list of "The Higher Vertebrates of British Guiana" only four species of the order Crocodilia have been found in this colony, all belonging to the genus *Caïman*, *C. niger*, *C. sclerops*, *C. trigonatus* and *C. palpebrosus*.

In spite of the fact that they are all caimans, the crocodilia of this region are always spoken of as *alligators*, with the exception, perhaps, of the black caïman, *C. niger*. This last named is the giant of the South American crocodilia, reaching a length, according to Ditmars, of twenty feet. A large specimen in the museum at Georgetown has a length of about ten feet and the skin of a somewhat smaller specimen was seen at H. M. Penal Settlement which is located about forty miles up the Essequibo River, near Bartica. The black caïman is apparently found almost exclusively along the upper reaches of the Essequibo and other rivers, though it may occasionally stray or be washed, in time of flood, nearer the coast. It is the one that has the reputation of being a man-eater, and is hence feared by the natives.

The native hunters say that the smaller, coastal forms are often dangerous in attacking those who rob their nests of eggs. It is even stated, as noted by Beebe,¹ that the caimans sometimes "will obstinately remain sprawled over their precious rubbish heap and have to be killed before the nest can be robbed." The writer either opened himself, or saw opened nearly two dozen nests, most of which contained eggs and in no case did the caïman appear to defend her nest. The same indifference has been experienced in collecting the eggs of the much larger Florida alligator, *A. mississippiensis*. The writer also waded many times through the surrounding swamps, sometimes neck-deep in mud and water, in visiting nests, but was never molested by the supposedly anxious mother.

While there may be a germ of truth in these hunters' tales, it is quite possible, judging from some of their other fabrications, that these stories about the dangers of alligator hunting are for the purpose of justifying the high price they ask for eggs, and to discourage others from entering their particular profession, since "profession" it must

¹ Zoologica, Scientific Contributions of the New York Zoological Society, Vol. 2, Nos. 7, 8, 9; 1919.

² Tropical Wild Life in British Guiana, New York Zoological Society, 1917.

be as one of the well-known negro hunters of Demerara styles himself "Professor".

With the exception of the black caiman, none of the genus in British Guiana seems to reach a length of more than eight or nine feet and even this size is unusual; whereas in the old days, when the Florida alligators were as abundant as the caimans still are in certain sections of British Guiana, monsters of almost twice this size were said to be not uncommon.

The abundance of the caimans varies in different localities without any apparent reason. On account of the hard, bony character of the hide, it is not likely to be used for commercial purposes as has been the case with the alligator, and this source of danger is not threatening, so that in spite of the collection of the eggs by the thousand by curio dealers, the caiman is said to be holding its own.

In the neighborhood of the Tropical Research Station the caimans are seldom seen. On the sugar and rice plantations near Georgetown and in the canals of the botanical gardens they are moderately common though one may wander about these places for days, during certain seasons, without seeing a single specimen, even though numerous nests may be found.

It is in the eastern part of the colony, in the Berbice region, that they are really abundant. Several were seen from the windows of the train, lying in the swamps along the track. During the rainy season, when practically this entire region is inundated and the cattle are seen wading in the water-covered "savannahs" eating the tops of the grasses that project above the surface of the water, the caimans wander and scatter over all these wide lowlands, and are only occasionally found along the "dams" or dikes that confine the waters of the irrigation canals. But during the dry season when the savannahs are no longer flooded and all the water is confined to the rivers and canals, the caimans are concentrated in the narrow confines of these waterways, and may be seen in astonishing numbers. They are considered such a pest by the managers of the estates that some of them offer a penny each for the destruction of the eggs. Whether the caiman does not serve a useful purpose in killing the destructive cane rats does not seem to have been determined.

The sole use to which the caimans seem to be put in British Guiana is as curios and as museum specimens. A few adults are killed and mounted and thousands of eggs are collected each year, as noted above, to be artificially hatched so that the baby caimans may be mounted in all sorts of postures and sold both in Georgetown and in other parts of the world.

The hunters call the caimans by making exactly the same grunting noise that is used by the hunters in the southern states in calling the alligators. As a matter of fact, the writer has seldom if ever seen a crocodillian respond to the call; since sound made in the air probably scarcely penetrates the water at all, the grunting could not be heard

by an animal unless its head were above the surface, especially as the ears are tightly closed by valves when submerged.

Native hunters apparently do not distinguish with any degree of certainty between the species, except between the black caiman, on the one hand, and all of the smaller forms, on the other. One will describe differences of color, for example, and talk of white and dark alligators. Another will describe characteristic markings, as noted by Beebe, *loc. cit.*, who figures the three types thus distinguished,—the Gooseway, in which the four or five transverse dorsal bands, between the front and hind legs, are continuous across the back; the Abary, in which the bands are interrupted in the mid-dorsal line but the half bands are opposite each other; and the Goomasaka, in which the bands are interrupted in the mid-dorsal line and are not opposite each other but alternate, a band on one side being opposite the space between the bands on the other side.

A study of the marking of adults, young and embryos seems to prove that this variation in the dorsal bands is a mere individual variation. For example, the dorsal stripes on three specimens, all evidently of the same species, showed the following variations: Number 1, three feet long, had eight transverse stripes across the tail, four across the body between the fore and hind legs; the body stripes were interrupted in the mid-dorsal line, the first and fourth half-stripes being opposite, the second and third being alternate; Number 2, four feet long, had six tail stripes, of the four body stripes, the first and fourth halves were opposite, the second and third were not quite opposite, the second being more nearly opposite than the third; Number 3, four and a half feet long, had eight tail stripes, and the body stripes approximately but not exactly like those of number 2. In older specimens the stripes are often quite indistinct, but are brought out more clearly by the varnish that the hunters apply in preparing the skins for the tourist trade.

That these variations in the black dorsal bands are a matter of merely individual variation is more conclusively proven by a study of the markings of the embryos from the same nest of eggs, it being pretty safe to assume that, unless a particularly large number of eggs is found, all the eggs in a single nest were laid by the same animal. In such a group of embryos all sorts of variations are seen, a few of which are shown in Fig. 1, outlined from a photograph of a series of embryos removed at intervals from eggs taken from one nest.

The nesting habits of the coastal forms have been briefly described by Beebe, *loc. cit.* pp. 283-5, and they resemble quite closely those of the Florida alligator as described by the present writer.⁵ Whether there be any differences in the nesting habits of the closely related species of Caiman it is impossible at present to state, but no great difference would be expected.

Nesting is said to begin in April, though this seems doubtful from the time of egg-laying. According to some hunters (Beebe, *loc. cit.*)

⁵ The Breeding Habits of the Florida Alligator, Smith. Misc. Coll., No. 1696, 1917; The Alligator and its Allies, New York, 1915.

there are twenty or more females to one male, which again seems very doubtful. Of five animals killed in one morning in the neighborhood of a number of egg-filled nests, all were males. The difficulty the writer experienced in securing females from which eggs might be obtained would seem to indicate the reverse condition to exist, i.e., the males outnumber the females. The intromittent organ of the male is completely hidden in the cloaca, so that it is impossible to distinguish the sexes by superficial examination. Without killing and carefully examining a large number of specimens the proportion of the sexes can hardly be stated with certainty.

It is usually said, as in the case of the alligator, that the female caiman builds the nest. In the former case it is built of flags, grass or whatever herbaceous growth is abundant in the immediate neighborhood. In the case of the caiman it seems often to have been built largely or entirely of the loose, often fine, vegetable trash that the animal scrapes up from the ground. Often it contained pieces of spiny palm that pierce the fingers as the eggs are removed from the nest.

Two statements are commonly made in regard to the method by which the heat, supposed to be necessary for the incubation of crocodilian eggs, is generated. The older idea that the heat of the sun's rays warms up the eggs, does not seem consistent with the fact that many of the nests, perhaps always when possible, are built in the shade, often so located that the direct rays of the sun never strike them. The more generally accepted theory that it is the decomposition of the green vegetable matter that is the source of the heat, seems disproven by the fact that these nests are often built of vegetable matter that has apparently passed through those stages of decomposition that would be likely to produce an appreciable amount of heat. As described by the writer, some years ago,⁴ the eggs of the Florida alligator were incubated quite successfully in a box of damp saw dust which served merely to keep the eggs moist and at a fairly constant temperature.

Figure 2 is a nest built on the bank of a canal, on a sugar estate, where there were practically no trees; this nest was exposed to the full glare of the tropical sun almost all day long. In every case observed the nest was within a few feet of the water; that shown in Fig. 2 was less than three feet from the edge of the canal and about one foot above the surface of the water. One nest, in a dense thicket, was built between the stems of a group of bamboo and other plants that stood so close together that it was difficult to reach between them to dig out the eggs; it must have been quite difficult for the alligator to build the nest in such a locality and then lay the eggs in it. Along the top of one "dam" near the Abary River, at least a dozen nests were found within a half mile, all built in a low, dense growth of brush and small trees where the sun seldom if ever reached them.

The general appearance of the nest of the caiman is not very different from that of the American alligator, though it probably does not average

⁴ The Development of the Florida Alligator, Smith. Misc. Coll., No. 1791, 1908.

so large. Occasionally an especially large nest is found, such as the one mentioned above which was built amongst the bamboo stems; this nest was large enough to fill a good sized cart and was comparatively loosely packed. On the other hand, the nest shown in Figure 2 was quite small and flat, and was packed so closely and baked so hard on the surface that it had to be dug open with a "Cutlass," the heavy knife that is used in South America for all sorts of outdoor work. This small nest contained twenty-three average sized eggs in which late embryos were found. On top of the nest were two or three growing plants that must have started their growth after the nest was built. In the abnormally large nest there were twenty-nine average sized eggs.

The eggs are laid in an irregular mass, Fig. 3, near the very bottom of the nest. Whether age or species have anything to do with the character of the nest it is not possible to say.

Several nests that were dug open were found filled up and rounded off again when visited a couple of days later; this was the case even with one nest from which the eggs had been removed. The caimans lay in these opened nests and no not seem to be disturbed by their having been opened.

As in the case of the alligator, the caiman, sometimes at least, seems to crawl over the nest, probably with the idea of packing it down, as a groove made by the tail may often be seen across the top of a newly made nest. According to one of the best known hunters, the finished nests are higher and more pointed than the incompleated ones, but this distinction certainly does not always hold, as in the case of the nest shown in Fig. 2.

It is commonly said that the caiman may build its nest several weeks before the eggs are deposited in it; this is doubtless true with the caiman as with the alligator, and one well-made nest of the former animal was visited by the writer nearly everyday for almost three weeks but no eggs were laid up to the time of his departure from that region; possibly the animal had been killed or scared away in the meantime.

The time of laying seems to begin about the middle of May or perhaps sooner and to last a month or more. The hunters differ among themselves as to the extent of the season and the same hunter will give different dates to different inquiries. It is possible that the time of egg laying varies somewhat with the weather conditions as in the case with the alligator.

The number of eggs in a nest is subject to considerable variation. Various numbers were given by hunters for the maximum. Eighty eggs in one nest were claimed to have been seen by one hunter; if this large number was actually found, it is likely that two animals laid in one nest, though it is doubtful if this ever happens. Others claim to have found forty-five, fifty, sixty, etc. eggs in a single nest. The largest number found in any of the nests under discussion was forty; the samllest number was eighteen. The average number of eggs per nest in the twenty nests studied was 27.15.

One hunter claimed that the larger animals laid the greater number of eggs and that their eggs were larger. Another hunter stated that the size and number of eggs varied with the species. It is doubtful if either man had any real information upon the subject as it would be very difficult to acquire.

There is considerable variation in the size of eggs, especially in eggs from different nests. The egg is typically a perfect ellipse, the two ends being alike. In three or four cases, however, eggs were found that were more pointed at one end than at the other; this was never seen with the eggs of the alligator.

Of 284 eggs whose long and short diameters were measured the average length was 57.77 mm.; the average short diameter was 36.85 mm. The longest egg was 69.5 mm.; the shortest 44.0 mm., giving a maximum variation in length of 25.5 mm., or more than 50% of the length of the shortest egg. The widest (short diameter) egg was 41.5 mm.; the narrowest egg was 30.5 mm., or a maximum variation of 11.0 mm. It will be noticed that the maximum variation in width is less than half the variation in length, which is, perhaps, what would be expected. The average variation in length was 5.34 mm.; the average variation in width was 2.94 mm. In the individual nests the greatest variation in length (between the longest and shortest eggs) was 7.5 mm.; the least variation (between the longest and shortest eggs) was 4.5 mm. The greatest variation in width was 4.0 mm. less than the least variation in width; the least variation in width was 1.0 mm., showing a remarkable uniformity in diameter. Whether this great variation in size of eggs from different nests is due to animals of different sizes or of different species can not, as noted above, be stated with certainty.

There is also considerable variation in the texture of the shell. In many nests the shell is comparatively smooth, though rougher than the shell of the fowl's egg; in other nests the surface of the shell is extremely harsh. As in the case of the variation in size, the relation of the character of the shell to the species or age of the animal is unknown.

The exact length of the incubation period is unknown. In fact it probably varies considerably under different conditions but is probably between two and three months.

On leaving Georgetown about August 1, three caiman eggs from a set from which late embryos had been removed some days before, were packed in a small basket, in some of the fine humus from the nest. This basket was packed among some clothes in the writer's trunk. These eggs were thought either probably to be infertile or to contain dead embryos. Although the trunk was frequently opened in the state-room during the twelve days voyage, the eggs were unchanged and were not disturbed. A couple of days after landing in New York, when the trunk was again opened a little caiman had completely hatched and another had succeeded in breaking the shell but had died in the attempt to escape. The third egg failed to hatch. The caiman that had escaped

from the shell seemed weak, possibly from the close confinement in the tiny basket and lived only a few days. These eggs were obtained on June 8 and had then apparently been laid for two or three weeks so that the time in this case from laying to hatching was somewhat over ten weeks.

It is likely that the female caiman digs open the nest at the time of hatching, as does the female alligator, since it would seem absolutely impossible for the just-hatched young to dig their way out of the compact mass of vegetation under which they are buried.

The average number of infertile eggs in 212 that were determined with certainty was a little over 6%. The greatest percentage of infertility in any one nest was slightly over 15%. Nearly half of the nests recorded had no infertile eggs at all.

When first laid the eggs are pure white, but they soon become stained with the humus of the nest, Fig. 4. The uniform white color of the eggs is broken within a day or two after laying by the same white band that has been described in the alligator egg. This band attains a width of two or three centimeters and extends around the smaller circumference of the egg. It is found, when the shell is picked away that the white band is due to a chalky appearance in the shell membrane.

On opening the egg the white is seen to be clear, not greenish as in the Florida alligator. It is stiff, however, as in the latter form, and can be easily cut or pulled away from the yolk. The whole contents may be poured out of the shell and will retain, more or less, its shape in the hand.

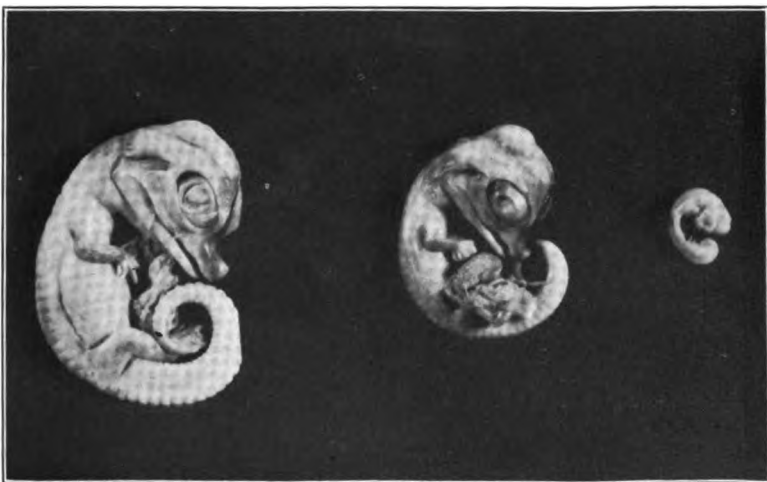
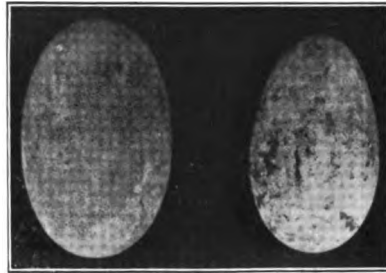
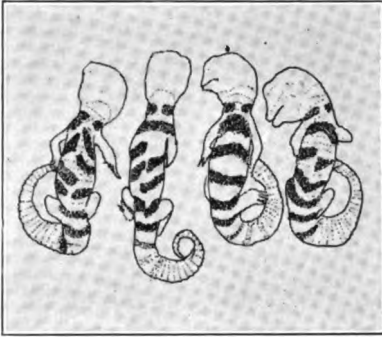
The bright yellow yolk is between thirty-five and forty millimeters in diameter and is surrounded by a tough vitelline membrane which holds together while the yolk, freed from the surrounding albumen, is passed from hand to hand.

The early embryos of the caiman are much smaller than the corresponding stages of the alligator and in the freshly opened egg are so transparent that they are very difficult to find and still more difficult to remove from the yolk. This is particularly true of the stages soon after the formation of the white band; for some reason, at this time, the vitelline membrane is so closely adherent to the inner shell membrane that it is almost impossible to remove the embryo without rupturing the former membrane, which allows the yolk to escape and the embryo to be lost. After a few minutes in the fixing fluid (sublimate-acetic gives excellent results) the embryo becomes white and opaque and is easily seen and handled.

The later stages are of course easily removed and the egg may be handled freely without any danger of injury to the contained embryos. In one case, the shell was removed from above the well formed allantois of a late embryo, leaving the embryo in its amnion and the vascular allantois exposed to the air. Under an inverted stender dish as a moist chamber, this embryo showed by visible motions, that it was alive for at least thirty-six hours.

Description of Figures

- Fig. 1.** Outline sketches of four embryos, all from the same nest, to show variations in markings.
- Fig. 2.** A nest on the bank of a canal, in the full sunlight.
- Fig. 3.** Near view of the uncovered eggs in the nest of the caiman.
- Fig. 4.** Two caiman eggs showing variation in size and shape. The egg on the right has the normal shape.
- Fig. 5.** Three sizes of caiman embryos.



THE ENZYMES OF THE BLOOD CORPUSCLES OF THE MAMMAL AND OF THE AMPHIBIAN

BY WITHROW MORSE, SOBISCA HALL AND U. O. SANDERS

Presented in abstract form to the American Society of Biological Chemists, Toronto, Ontario, December 27, 1922.

In order that the following paper which is of somewhat technical aspect may be intelligible to the general reader, the editorial committee wishes to say that the primary interest of the paper is that those minute corpuscles which float in the blood and which bear the coloring matter of the blood are cells similar to those fundamental units of which the whole body is composed and that these cells in the mammal differ from those in the lower forms inasmuch as the mammalian (dog, rabbit, etc.) corpuscles lose their nuclei or central, controlling body while this is retained in the blood of the salamander to which the urodele (mud-puppy) belongs. It has been proven by a number of investigators that typically, all cells bear certain ferments or enzymes capable of digesting different things, proteases digesting proteins (meat-substances), lipases digesting fat, etc. The present work, however, shows that these cells, whether endowed with a nucleus or not, do not contain these enzymes save one or two. Blood kept free from bacteria will remain unchanged for months, while liver will undergo dissolution, or autolysis ("self-digestion") within a few hours. One other point: It is possible in some cells to cut away the nucleus and in that case the cell invariably dies. The red blood corpuscle of the mammal is in the condition of a cell the nucleus of which has been removed and it is to be expected that such cells should lack enzymes for it is the function of the nucleus to manufacture enzymes. However, the following pages show that not alone the nuclei-free cells of the mammal, but also the nucleated cells of the mud-puppy show the absence of many enzymes found in other cells, such as those of the liver.

INTRODUCTION

One¹ of us has reported recently that washed erythrocytes of the mammal (dog) exhibit no autolysis after long standing. In order to determine whether the erythrocytes of the mammal lacked, also, enzymes ordinarily found in cells throughout the body, the study was extended to those enzymes mentioned in the next section of the present paper. Inasmuch as the mammalian erythrocyte, according to the research of Wright and of others, becomes enucleated during the early period of its sojourn in the blood, it was conceivable that the absence of enzymes which we observed, might be due to the lack of a nucleus and in order to determine whether nucleated cells bearing haemoglobin possessed a complement of enzymes, attention was directed to those of the mud-puppy, *Cryptobranchus alleganiensis*, where the large erythrocyte bears a conspicuous nucleus.

METHODS

In each case, whether of dog, rabbit or mud-puppy, the blood was received in potassium oxalate solution² and centrifuged, the leucocyte and platelet layer being generously decanted from the erythrocytes, the original volume being made up by means of 0.9 gram NaCl per 100 ML H₂O. This was repeated several times to insure that no leucocytes, long known to possess various enzymes, remained to contaminate the erythrocytes and also to insure that all plasma was removed, so that there would be no anti-enzyme action from such substances known

¹ Morse, Withrow. Journ. Biol. Chem. 1921.

² Of a strength recommended by Folin in his system of blood analysis.

to be contained in blood-plasma. Chloroform and toluene were used for antiseptic purposes and since Yamakawa^a has shown that CHCl_3 inhibits the action of anti-enzyme of the plasma, this acted as a further safeguard in our experiments.

The tests, all of which were quantitative, were then conducted uniformly as follows: Erythrocytes, in their original volume of physiologically normal saline, were pipetted into small vessels (test-tubes or erlenmeyer flasks of pyrex or of jena glass) and brought into contact with the zymolyte,^c whatever it may be—starch, ester, oil, etc. Controls were conducted, in each case.

PROCEDURE

Protease: Blood was left to autolyze at standard temperature. Macro-Kjeldahl total nitrogen determinations were made upon tri-chlor-acetic (5%) filtrates after the proteins were precipitated. Typical results with *Cryptobranchus* blood are as follows: (averages)

Initial Kjeldahl determination.....2.8 ML 0.1 N acid.
Seven day digest. determination.....2.3 ML 0.1 N acid.

Neither the blood of the dog nor of the urodele exhibited the evidence of protein hydrolysis. On dialysis, the PH by colorimetric method gave 6.8.

Esterase: Merck's Ethyl acetate N.F. IV running 25.5 grams to 28.0 grams of the solvent was placed in contact with erythrocytes one volume of each. Titrations with decinormal alkali with phenolphthalein as indicator at the beginning and at the end of the period of the experiment gave no difference, indicating that an esterase capable of hydrolyzing the lower esters was absent.

Lipase: One volume of olive oil was added to a volume of erythrocytes and the preparation was left for seven days. (dog blood).

Control 0.4 ML 0.1 N. alkali.
Experiment 1.5 ML 0.1 N. alkali.

It is evident that there is evidence for the presence of a lipase. It is interesting to note in this connection that Saxl^d found slight traces of esterase capable of hydrolyzing higher tri-glycerides. It is improbable that the results are due to oxidation of the oil in contact with the erythrocytes, for Dunn^e reports the absence of oxidizing enzymes in mammalian erythrocytes. An enzyme, capable of hydrolyzing lecithin has been shown by Thiele^f to occur in blood, but apparently it is confined to the plasma. An enzyme hydrolyzing cholesterol esters is reported by Cytronenberg^g to occur in the blood.

Invertase: Saccharose in 1% solution in water was placed in contact with erythrocytes in equal volumes. Benedict quantitative method was employed, giving negative results.

^a Yamakawa, 1918. Journ. Exp. Med., 27, 689.

^b Using Loewenhardt's expression for the less exact "substrate."

^c Saxl, 1908. Biochem. Zeitschr., 12, 843.

^d Dunn, 1913. Quart. Journ. Med., 6, 293.

^e Thiele, 1918. Biochem. Journ., 7, 275.

^f Cytronenberg, 1912. Biochem. Zeitschr., 45, 281.

Catalase: Merck's superoxyl was used. Immediately after exposure of the erythrocytes to the solution a great evolution of gas occurred. Since this is such a well-known phenomenon with whole blood and since Battelli and Stern⁹ and others have given attention to it, we did not examine the problem further. Golodetz and Unna¹⁰ have shown that this enzyme if such it be, exists in the cytoplasm of the cells in which it occurs.

Amylase: Potato starch in 1% suspension was used. Benedict's method was utilized to detect any hydrolysis. The results were negative. Satta¹¹ followed this enzyme into the blood-albumen fraction on salting out the proteins of the blood and hence it is probable that it exists only in the blood plasma.

DISCUSSION

Mathews early showed that zymogens, or pro-enzymes occurred in the nucleus of cells, such as the pancreas, an observation which Macallum corroborated. Hence, it is to be assumed that enzymes have their birth in, or near the phase-boundary of the nucleus, which occupied the same importance here as in all colloidal configurations. One may readily demonstrate the inception of spicules of sponges, secretions of glands, etc., at this interface. It is to be expected therefore that in the erythrocytes of the mammal where these central governing corpuscles are extruded from the stroma of the erythrocyte, enzymes will be found lacking, unless they are retained after the expulsion of the nucleus. From the observations given above, it is apparent that they are not absorbed or otherwise retained. We were not prepared, however, to find an identical situation in both erythrocytes of the mammal and of the lower chordate, the urodele. The evidence for lipase and for catalase in both is significant. From the observations presented it appears that the erythrocyte of the urodele is as typical regarding its enzyme content as that of the mammal and that in both cases we have a very highly specialized cell, the sole function of which in all probability being that of transference of oxygen and of CO₂. The short life of the erythrocyte of the mammal was pointed out a century ago by Hunter.

CONCLUSION

(1) No difference was found between the nucleated and enucleated erythrocyte regarding the content of enzymes.

(2) In both the mammal (dog, rabbit) and in the salamander (urodele) *Cryptobranchus*, but two enzymes were found to be present, namely, an esterase of the higher tri-glycerides (olive oil) and catalase.

(3) The nucleated cell of *Cryptobranchus* does not undergo autolysis, thus resembling the erythrocyte of enucleated nature of the mammal.

(4) The erythrocyte of whatever sort is a highly specialized cell given over to respiratory functions, its life in the blood stream being of short duration and its maintenance being made by the medium in which it floats (the blood plasma).

⁹ Battelli and Stern, 1911. Biochem. Zeitschr., 33, 315.

¹⁰ Golodetz and Unna, 1912. Berlin, klin. Wochenschr., 49, 1134.

¹¹ Satta, 1915. Arch. Sci. Med., 39, 46.

A SLIDE RULE REPRESENTATION OF EINSTEIN'S RESTRICTED THEORY OF RELATIVITY

BY CLARENCE N. REYNOLDS, JR.

Assistant Professor of Mathematics, West Virginia University

The fundamental problem considered by Einstein is that of taking into account the previously unsuspected effects of the force of gravitation and the motion of the observer upon such physical measurements as he may make. We all understand the ordinary relativity of uniform motion, and the confusion which it sometimes causes, by recalling our experiences while travelling when we are sometimes in doubt whether our own train or the train on the next track is in motion. The two theories of relativity proposed by Einstein go much further than this. In the earlier theory he assumes that it is impossible for an observer to distinguish experimentally between a state of rest and one of uniform motion with respect to the ether, while in the general theory he assumes that it is impossible to distinguish between an observer subject to gravitational forces and an observer who is moving through space with a varying velocity.

The importance of Einstein's theories of relativity and gravitation is due to the fact that in developing them he has discarded many of the most fundamental notions upon which physical science has been based. It will therefore be advisable for us to review briefly some of these fundamental ideas.

Upon examining what we may call the orthodox physical theories of sound, heat, light and electricity we find that in each case the mathematical physicist is satisfied as soon as he has reduced a particular class of phenomena to mathematically defined motions of molecules, electrons, or the ether. In general, however, we may say that these moving bodies are not observed directly. Indeed, the only evidence which we have of their existence is the fact that the theories which we base upon them enable us to describe completely and consistently the phenomena which we do observe. Such a description in terms of these motions is generally labelled an explanation.

The reader may be surprised that I fail to mention the forces with which the experimental physicist works. Physical forces, however, are just as hypothetical as electrons, never being observed directly. We only observe non-uniform or accelerated motions and wonder why they are not uniform, since we have a strong prejudice which leads us to believe that freely moving bodies "naturally" travel in straight lines with a uniform velocity. If we had no such feeling we would have no occasion to speak of the forces which are said to "cause" accelerations. Einstein abandons this prejudice and open-mindedly sets out to discover what are the most natural motions of freely moving bodies. Consequently he has to go back to the more fundamental problems

of the measurement of space and time, since motions can only be described in terms of space and time.

The physicist has, in the past, always assumed, first, that the space which he measures is the space considered in the familiar geometry developed by Euclid, and, secondly, that the measurement of time is independent of the measurement of space. Meanwhile, mathematicians have, for several decades, realized that Euclid's geometry is not the only logically consistent geometry and have developed various non-Euclidean geometries. And now Einstein finds that a considerable portion of physics can be simplified by assuming that space and time are organically related to each other, three dimensions of space and one of time being combined in one non-Euclidean whole.

Finally, he has introduced a new definition of uniform velocity. Just as the physicist has been accustomed to defining equal intervals of time in terms of a particular example, namely, the interval required for one rotation of the earth about its axis, so Einstein defines a standard unit of velocity for all observers, regardless of their motions, as the velocity of light passing through a vacuum free from the influence of gravitation. This definition was suggested by the failure of many attempts (notably that of Michelson and Morley) to detect a variation in the velocity of light according as the observer moves with or against the stream of light while making his measurements. In all cases the velocity of light has been found to have a constant value (about 186,000 miles per second) which we shall denote by the letter c .

This definition and the earlier or restricted principle of relativity imply the new principles of mechanics which Einstein developed in 1905. As an example from this part of the theory we shall study the relation between the units of time and space used by two observers who are moving with reference to each other with a uniform velocity three-fifths of that of light, as illustrated by the accompanying relativity slide rule.

By means of this rule we shall represent the clocks and linear scales used by two observers, one of whom we shall call the stationary observer, is supposed to be on the frame of the rule and to use the clock t and the horizontal scale x . The other, the moving observer, moving to the right with a velocity three-fifths that of light, is supposed to be on the slide and to use the clocks T and T_1 , and the horizontal scale X . The scales are graduated in multiples of c where c represents the distance which light travels in one second, about 186,000 miles.

The scale which actuates the clock t is so adjusted that the clock reads zero seconds when o and O_1 , the zeros of the x - and X -scales, are opposite each other; and reads five seconds when O , the zero of the X -scale, is opposite the $3c$ of the x -scale. In this way we make the velocity of the slide $3c/5$ as measured by the stationary observer.

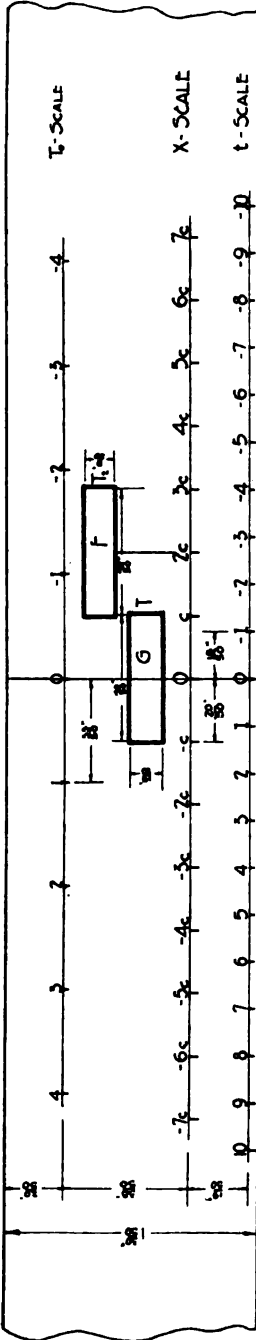
Now let a light signal be sent vertically by a physicist stationed at O on the slide. Let this signal leave O when the clock t reads zero seconds, and let it strike a mirror from which it is reflected back to O ,

returning to O at the instant when the clock t reads five seconds. At that instant, as we saw above, O will be opposite the point $3c$ of the x -scale. Therefore, from the point of view of the stationary observer the light will have traversed the legs of an isosceles triangle whose base is $3c$. Furthermore, since the experiment lasts five seconds, he concludes that the light signal has covered a total distance of $5c$. By elementary geometry the student can readily prove that the altitude of an isosceles triangle with $3c$ for a base and $5c$ for the sum of the equal sides must be $2c$.

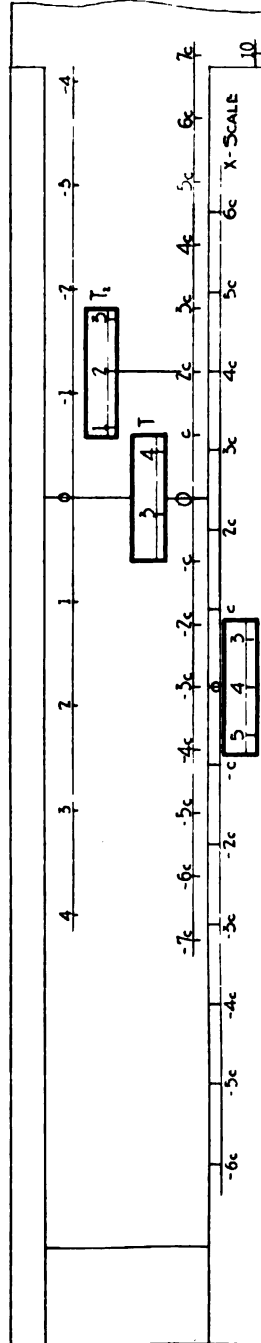
This altitude is measured along the vertical scale which is used by both the stationary and the moving observers. Therefore the moving observer will conclude that the light signal considered in the last paragraph covered a distance $2c$ and then returned over the same path, thus covering a total distance of $4c$. Since both observers obtain the same measure, c , for the velocity of light, the moving observer must conclude that the experiment lasts four seconds. Hence four seconds according to the moving clock T will be equal to five seconds according to the stationary clock t . Therefore, we conclude that *if one of two observers is in motion with respect to the other then time appears to lapse at different rates for the two observers*, a conclusion which is contrary to our intuitive notion that time lapses at the same rate for everyone.

If a similar experiment be performed in which a light signal leaves O when the clock t reads zero seconds, travels to the right, meets a mirror, and returns to O when the clock t reads five seconds, and, as we saw above, the clock T reads four seconds, then a moving observer will conclude that the light travels a distance $2c$ to the right along the X -scale and returns. For the stationary observer the situation is more complicated. He concludes that the light has covered a total distance of $5c$ since the experiment, as before, lasts five seconds. This distance, however, has been covered in such manner that the light finally, when the clock t reads five seconds, arrives at the point $3c$ on the x -scale. Therefore he finds that the light first travels a distance $4c$ to the right, along the x -scale, where it strikes the mirror, and then travels a distance c to the left. That is to say, the point $2c$ on the X -scale must be opposite the point $4c$ on the x -scale when the clock t reads four seconds. In order that this may be so a study of the construction of the rule shows us that this will only be true when each unit on the X -scale is four-fifths as long as the unit on the x -scale. From this we conclude that *if one of two units of length which are equal when both are at rest moves in the direction of its own length with respect to the other, then it will appear to contract*.

When the light reaches the mirror at the point $2c$ on the X -scale the clock T , at that point must read two seconds if the velocity of light as measured on the slide is to be c . The reading of the clock T will, however, be four-fifths of the reading of the stationary clock t , or four-fifths of four, or sixteen-fifths of a second; i. e. $6/5$ of a second in excess of the reading of the clock T . Therefore two clocks on the moving slide will not in general appear to keep the same time as seen by a



SCALE C



THE RELATIVITY SLIDE RULE

stationary observer, the clock to the right being behind the clock to the left by a number of seconds equal to $3/5c$ times their horizontal distance apart as measured on the moving scale. In other words, *events which are simultaneous from the point of view of a stationary observer will not in general appear to be simultaneous from the point of view of a moving observer.*

We can obtain the "local Time" at any point on the slide by constructing a scale T , giving the reading of a local clock when the clock T at O reads zero seconds. The correction indicated by this scale when added to the reading of the clock T gives the required local time, which we shall denote by T' .

We now see that our rule has been so constructed that if an event has been determined in position and in time by the values of x and t , then we can by properly setting our slide determine the values of X and T' , and conversely.

EXERCISES.

Given: $t=0$, $x=4c$, show that $X=5c$, and $T'=-3$;

Given: $t=4$, $x=2.4c$, show that $X=0$, and $T'=3.1$;

Given: $T'=-.3$, $X=5c$, show that $x=4c$, and $t=5$;

Given: $x=4c$, $t=2$, show that $x=3.5c$, and $T'=-.5$;

Given: $X=0$, $T'=4$, show that $x=3c$, and $t=5$;

Given: $X=2$, $T'=10/3$, show that $x=5c$, and $t=17/3$.

One particularly interesting type of problem is that of determining the velocity of an object with respect to one observer if its velocity with respect to the other observer is known. For example, let an object move to the right with a velocity two-fifths that of light as measured by the moving observer on the slide which itself moves with a velocity three-fifths that of light. Here we would intuitively expect the velocity as measured by the stationary observer to be the sum of these velocities or the velocity of light itself. To show that this is not the case we shall let an object travel along the X -scale, passing O when the clock T reads 0 seconds and passing the point where $X=2c$ when the clock T , reads 5 seconds. Here the velocity as measured by the moving observer is the distance covered, $2c$ divided by the time, five seconds, or our given velocity, $2c/5$. By setting the rule we find that the distance along the x -scale is $25c/4$ while the time required as measured by the clock t is $31/4$ seconds. To find the velocity of our moving object as measured by the stationary observer we divide the distance covered, $25c/4$, by the time required, $31/4$ seconds and obtain as a result $25c/31$, a value less than the value which we obtain intuitively. In fact one of the implications of Einstein's restricted theory of relativity is that no material bodies can move with a velocity as great as that of light.

STEPS IN THE CONSTRUCTION OF THE RELATIVITY SLIDE RULE.

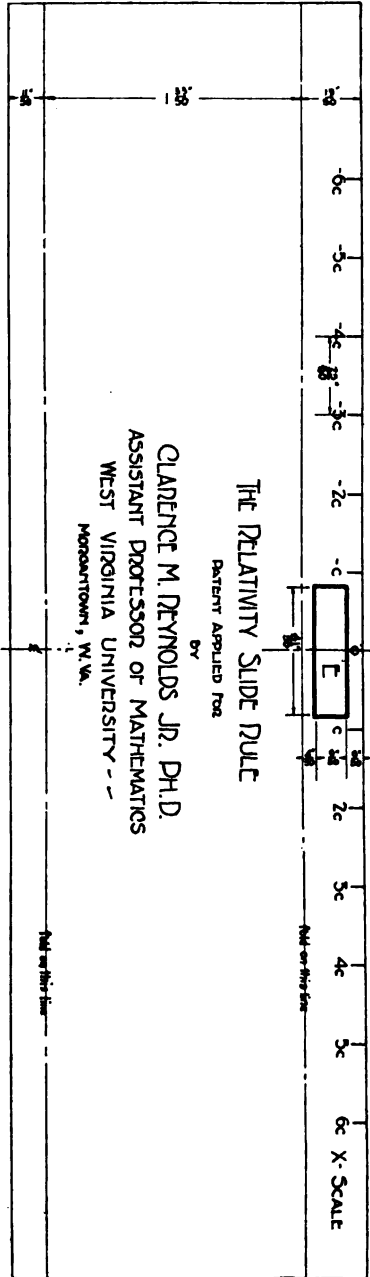
No. 1. After the pieces A, B, and C have been cut out the three openings D, E, and F are cut out with a sharp knife.

No. 2. A is folded along the dotted lines so that the printed scale is on the outside of the folded paper.

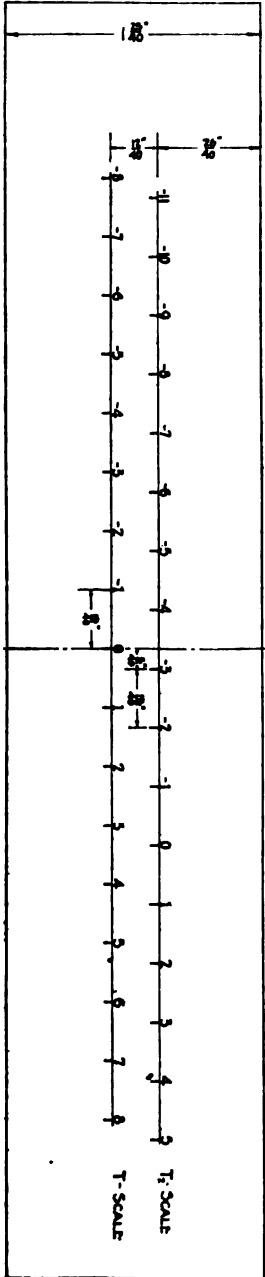
No. 3. B is pasted within A so that the three scales may be seen with the O of the T-scale opposite the O of the x-scale.

No. 4. The slide C is inserted under the folds of A so that the opening E falls over the t-scale.

Note: The results of this paper may be generalized to the case where two observers are moving with a velocity v with respect to each other if in the above discussion we replace the fractions $3/5$ and $4/5$ by v/c and the square root of the quantity $1-v^2/c^2$, respectively.



SCALE A



SCALE D

BULLETIN
of the
**WEST VIRGINIA UNIVERSITY
SCIENTIFIC ASSOCIATION**

VOL. III.
NO. I



December
1923

CONTENTS

CHEMISTRY NUMBER

	Page
List of Officers of the West Virginia University Scientific Association	2
Editorial Note	3
The New Chemistry Building; By Friend E. Clark	3
The Future Opportunity for Physical Chemistry at West Virginia University; By Earl C. H. Davies	7
Glass; By Hubert Hill	10
An Estimation of Impurities in Battery Acids; By Lily Bell Sefton Deatrick	18
The Action of Chlormethylbenzyl Ether on Salts of Organic Acids; By Friend E. Clark	24
A Reagent Bottle Siphon; By C. A. Jacobson	28
A Novel Calculating Machine; By C. A. Jacobson	30
Chemical Spelling Contest of 1921; By C. A. Jacobson	34
A Study of the Grading System in General (First Year) Chemistry; By Samuel Morris	39

OFFICERS
of the
West Virginia University
Scientific Association

PAST PRESIDENTS

A. R. Whitehill.....	1914-15
S. B. Brown.....	1915-16
F. E. Emory.....	1916-17
C. W. Waggoner.....	1917-18
B. H. Hite.....	1918-19
A. M. Reese.....	1919-20
Aaron Arkin.....	1920-21
N. J. Giddings.....	1921-22
R. P. Davis.....	1922-23

OFFICERS FOR 1923-24

President.....	G. S. Dodds
Vice-President.....	Geo. R. Bancroft
Secretary.....	J. H. Gill
Treasurer.....	E. R. Scheffel
Program Committee.....	{ J. H. Gill John L. Tilton R. L. Garber

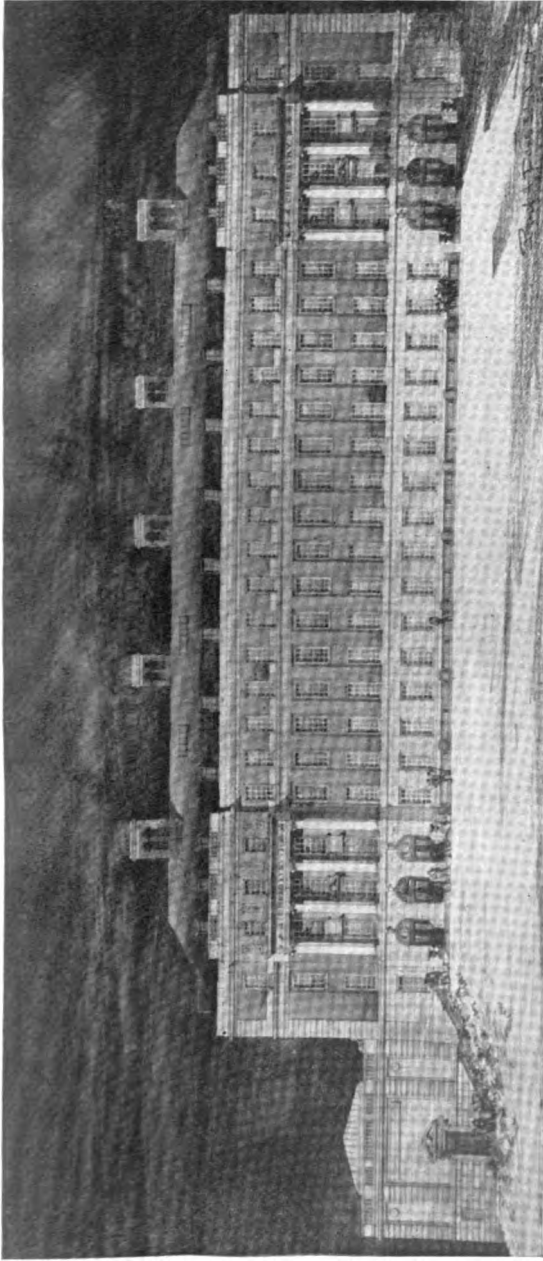


Plate 1: FRONT ELEVATION

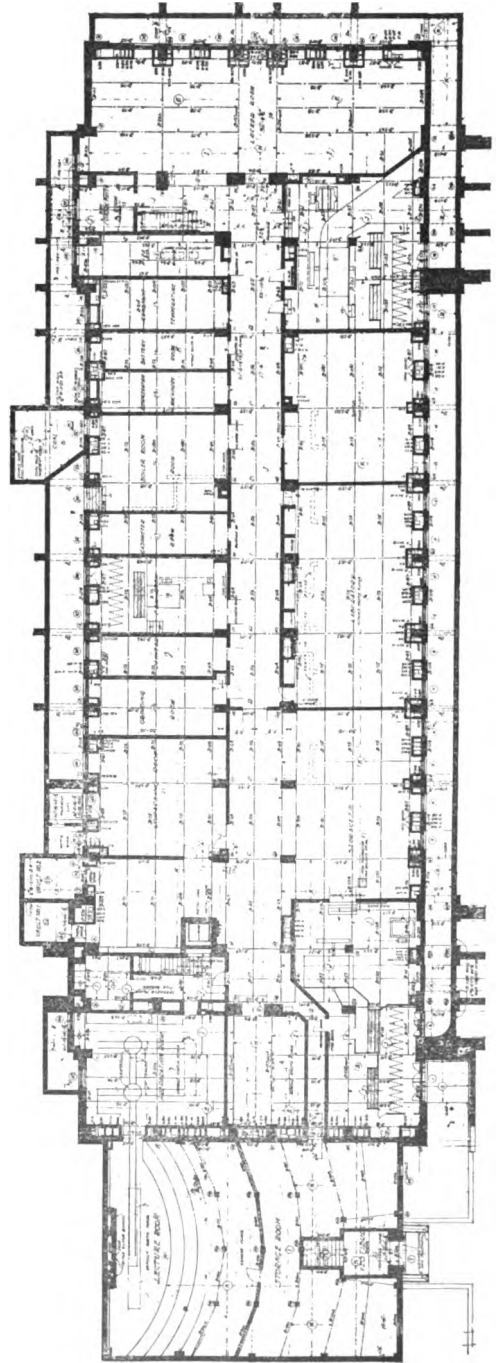


Plate 2: BASEMENT PLAN

EDITORIAL NOTE

The present number of the Bulletin of the West Virginia University Scientific Association is presented by the Department of Chemistry. Later in the year it is hoped a general number will appear containing personal items, abstracts of papers, and possibly a few scientific papers. The editorial committee appointed for 1923-24 consists of the following members: John L. Tilton, Chairman; N. J. Giddings, F. E. Chidester, W. W. Hodge and J. E. Winter.

THE NEW CHEMISTRY BUILDING

By FRIEND E. CLARK

Early in 1924, work will begin on the new chemistry building which was procided for by the legislatures of 1921 and 1923. The accompanying illustrations give most of the particulars as regards the proposed general appearance of the exterior of the building and floor plans. However, two important deviations from the picture here shown should be mentioned. The architecture of the exterior of the building will be somewhat different from that shown on front elevation (Plate 1), but the general size and dimensions conform to the details as shown on all plates. The second change is to be found on the basement plans (Plate 2), where the excavations will be about one-half of that shown. Reference to this detail will be made further on in this article.

The main sections of the structure will be four stories, together with a basement and attic. The dimensions over all are 305 x 79 feet, including an extension of the basement and first floor to take care of the large auditorium or lecture hall at the west end of the building. The auditorium will seat in excess of three hundred students. It will be entered either from the campus on the basement level or from the first floor, through a corridor leading from two entrances of the main portion of the building. Lighting of this lecture room will be entirely through the ceiling, as there will be no side windows. The shutters regulating the light will be manipulated by compressed air, direct from the lecture desk. The seats will be arranged in amphitheater style. The lecture desk is 28 feet in length, 10 feet of which is stationary, with the usual service equipment, drawers, cupboards, etc., as is also the front part of the remainder, but the rear part will consist of a light frame work of structural steel placed on a track leading to the preparation room to permit rapid changes

of equipment by the substitution of a duplicate section kept in readiness. This plan makes possible the use of the auditorium during consecutive hours.

The basement provides the general service of the building. Here are ample receiving and storage rooms with elevator connecting with distribution rooms on all floors, refrigerating room, including provision for a liquid air unit, shop, three fan rooms and a constant temperature room. The basement fans will force fresh air throughout the entire building, the circulation to be through cement conduits arranged under the area ways on the outside of the building, from which the air will be discharged into the various rooms through recessed conduits in the walls. The fan room to the east of the center of the basement, and certain service rooms, have been pushed towards the west; other rooms have been eliminated. This change was necessary in order to eliminate certain expensive excavation cuts. Emphasis should be laid on the fact that the practical service of the basement will be maintained.

The first floor will accommodate the department of physical chemistry and a part of general chemistry. A lecture room begins on this floor and extends through the second floor, thus throwing the height through two stories into the lecture room. Special storage rooms for research chemicals and apparatus have been provided on this floor, also a large locker room which is located between the large auditorium lecture hall and the laboratories, convenient to all sections of the building. Attention is directed to the balance rooms at either end of the building. These rooms are inside rooms and are so placed that the same section of each floor is similarly occupied. The lighting will be both from indirect units in the ceiling and from single electric lights over each balance case. Ventilation will be ample, the air being forced from the fans in the basement. Supplementary ventilation will be directed from fans in the attic.

The second floor will be arranged for general chemistry, with certain unusual provision for the future. The laboratories at the front of the building will have all equipment except desks. Temporary partitions will be installed in order to supply a number of recitation rooms, possibly to other departments, until this section of the building is needed for laboratory purposes. The general distribution room for student supplies is on this floor. It affords ample facilities for such service throughout the building. Other recitation rooms and offices are on this floor, also.

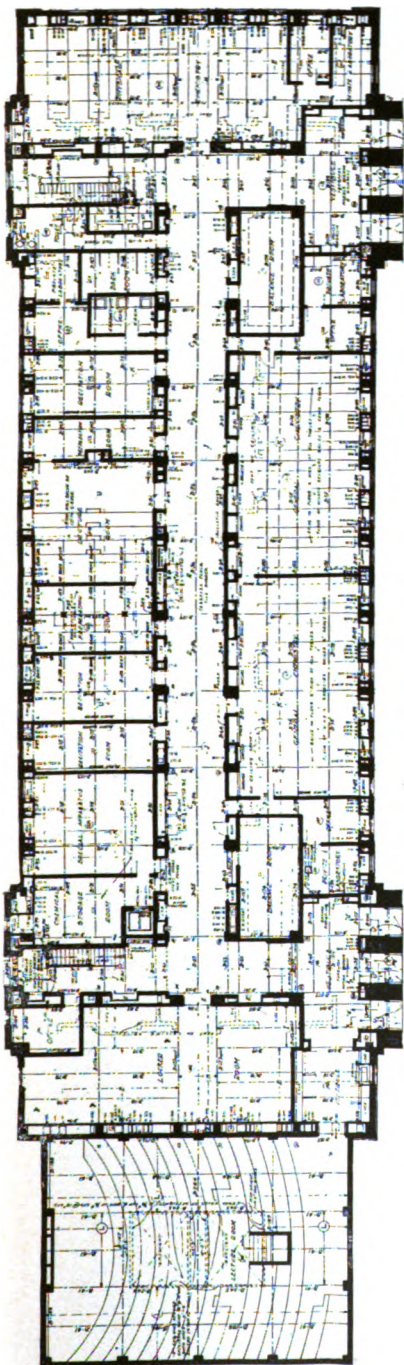


Plate 3: FIRST FLOOR PLAN

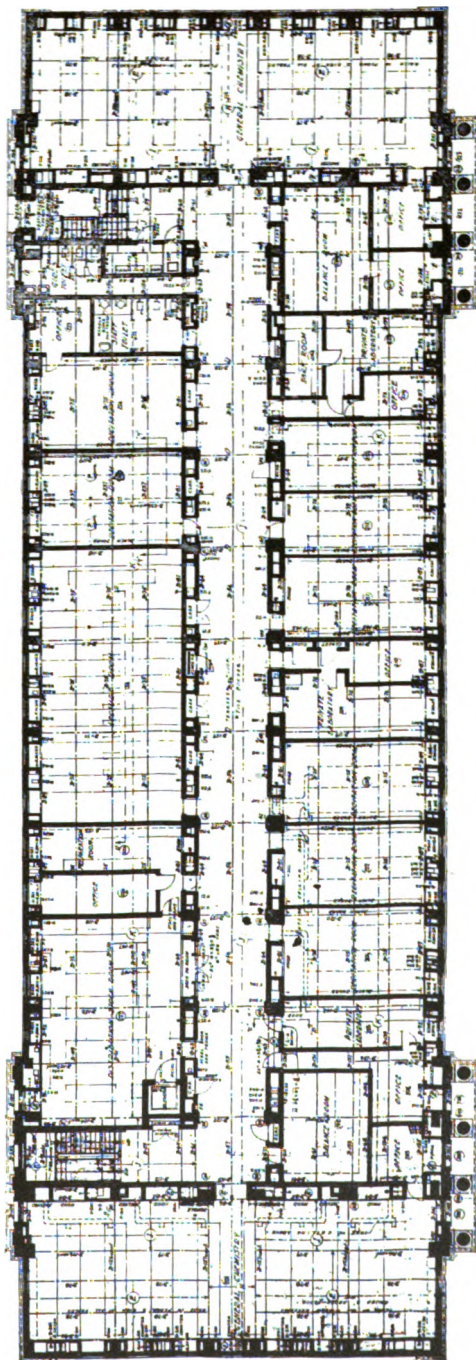


Plate A: SECOND FLOOR PLAN



The third floor has been planned to meet the needs of analytical chemistry. Many special provisions have been made to care for the varied work of this department, including separate laboratories for electro-chemistry. The departmental library will be on this floor, and it is hoped that all of the books relating to chemistry, which are now in the general library, may be kept here, under the care of a regular member of the University library staff. The room would be kept open throughout the regular hours of the general library. The general offices of the department are on the third floor.

Organic chemistry in its various synthetic and analytical relations will be taken care of on the fourth floor. To point to a certain completeness in the service of this floor, there is a Kjeldahl digestion room, a laboratory for organic combustions and a number of small research laboratories where a student or a small group of students may work with freedom from interruption. These laboratories are for the use of all branches of chemistry, and are located on the fourth floor in order to give as much quiet as possible.

In the attic will be an assembly room for informal gatherings of chemistry majors, also a place for chemical society meetings. Here will be the distilled water plant which will supply water to all sections of the building through block tin pipes. Here also is the source of supply for hydrogen sulphide. There will be two bed rooms for two or more students who will have care of the building at night. The ventilation system occupies much of the space of the attic, but there is provision for the future expansion of the department. The top floor will be adequately lighted by sky lights and dormer windows.

In a general way, it is of interest to note that the building will be of fireproof construction. There will be no plastered walls or ceilings in any of the laboratories. Indeed, all walls will be of brick and the ceilings of smooth cement. At the west end of the building on the outside wall, a fountain has been planned, with provision to care for a War Memorial Record.

The building has been planned for the future as well as for the years immediately following its completion. There are at present approximately eight hundred students studying chemistry in our present quarters in Science Hall. The new building will take care of more than three times that number and under modern working conditions.

The present staff of teachers feels keenly appreciative of the co-operation which has been given by the State Board of Control, the President of the University and State Board of Education. The architects, Paul A. Davis, 3rd, and Dunlap, of Philadelphia, are working to bring our chemistry building to the highest state of architectural beauty and efficiency.

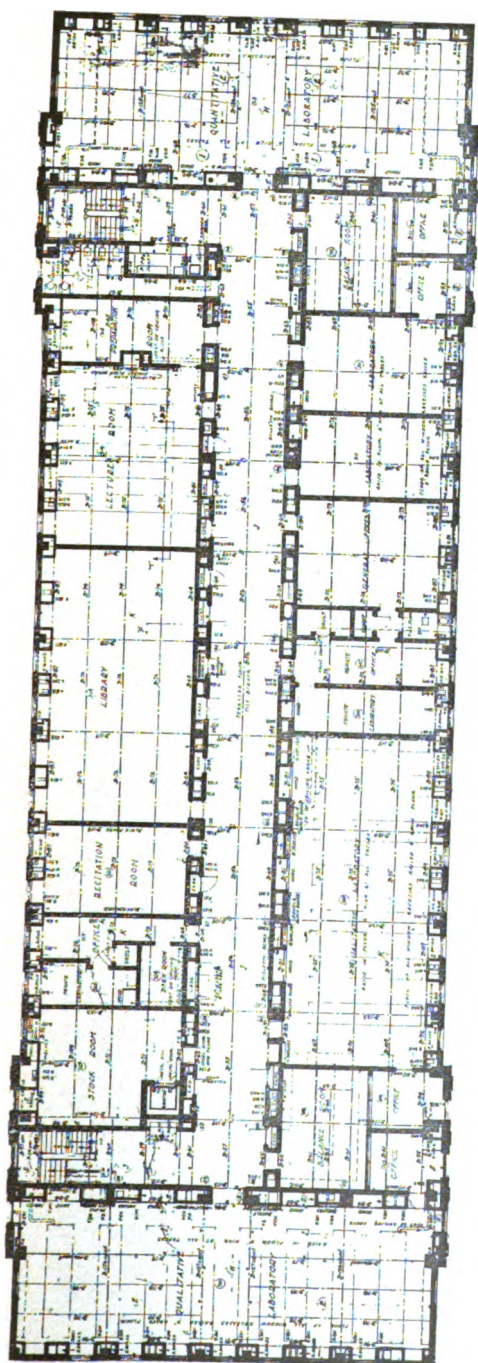


Plate 5: THIRD FLOOR PLAN

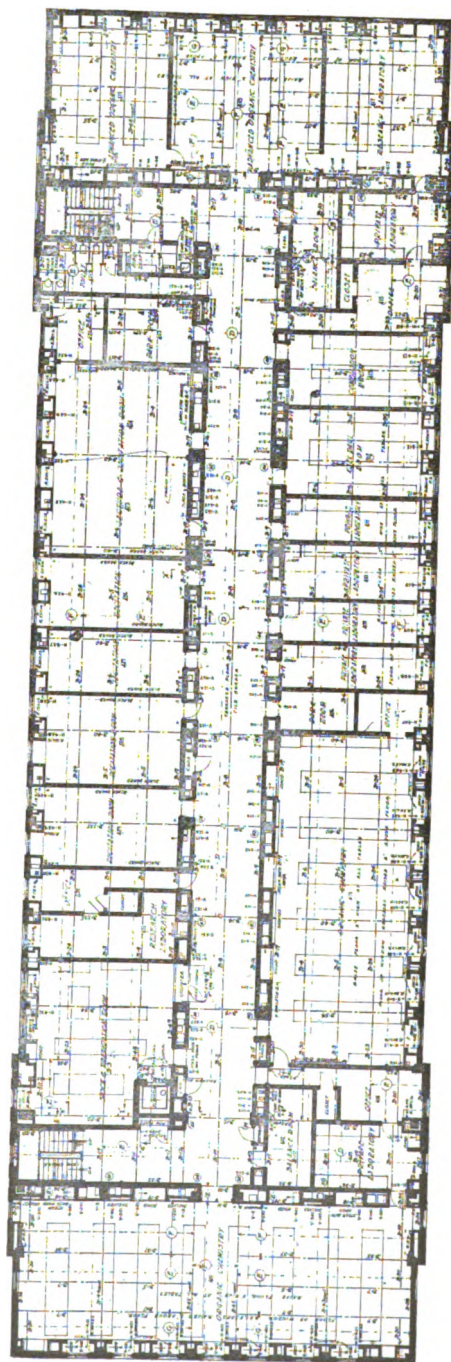


Plate 6: FOURTH FLOOR PLAN

THE FUTURE OPPORTUNITY FOR PHYSICAL CHEMISTRY AT WEST VIRGINIA UNIVERSITY

By EARL C. H. DAVIES

Physical chemistry attempts to systematize all the facts of chemistry and to discover the laws governing chemical action. At the border line between the two great sciences, physics and chemistry, physical chemistry freely uses the principles of both sciences. Only a few years ago it was possible to do extensive graduate work in chemistry without being required to take physical chemistry; but as the number of isolated facts have increased it has become necessary to correlate these facts into generalizations and laws. This has not been an easy task but it has been one of fascination. To collect thousand of facts in a single formula or statement is a great satisfaction. To have this formula or statement stand in the face of thousands of other facts yet undiscovered, that is even a greater achievement.

Physical chemistry is still in its infancy. During the past year our own Medical School has shown that the teachers are second to none in progressiveness and in a thorough understanding of the needs of modern medicine. By no single act could this have been shown better than by the request for a prescribed course in physical chemistry for pre-medical students. Such a course has been established with a first class of sixty students. One could not expect to get more hearty co-operation than was shown this year. It demonstrates that the desire to be thorough and modern permeates the entire Medical School from teacher to student. It is not desirable to enter into the many applications of physical chemistry to medicine. The action of the Medical School speaks for itself.

Similarly physical chemistry is a required subject for all chemistry majors and all chemical engineers. The School of Agriculture requires physical chemistry for some of its majors. This is a good beginning. We feel that as soon as the course can be worked into the schedule it will also be required for other lines of agriculture. One of the greatest "old school" chemists was Liebeg. He made extensive analyses of the various grains, hay, and other crops with the idea that he could then tell the farmers just how much of each element was removed from

each acre during the year. His contention was that it would then only be necessary to add these same weights of the elements and the soil would remain fertile. The farmers tried it and were so disgusted that they reversed the syllables of his name and called him Big-lies. This was simply because he did not recognize the importance of colloids and bacteria in soil fertility and plant growth. Some of us who listened to a lecture, given by Dr. Bryan while he was connected with our own Experiment Station, felt as if we were listening to a physical chemistry lecture on H-ions. It is indeed gratifying to one interested in this branch of chemistry to see that its importance is so widely recognized in the practical applications to every day life.

James F. Norris, Professor of Organic Chemistry at the Massachusetts Institute of Technology, has said, "The development of industrial chemistry in all its phases is rapidly taking place as the result of the application of the fundamental principles underlying the science, which are considered fully in physical or theoretical chemistry."

As it is now planned, the Division of Physical Chemistry will, in the proposed new building, have the most modern equipment. These laboratories will be located on the first floor which will make them conveniently close to a special still for making extremely pure water in large quantities. This still will be at the same end of the building but in the basement. Near the still will be an ice plant from which water at about 3°C. will circulate to the large thermostats. A liquid air machine of a capacity of about 1 liter per hour will be available near the ice plant. Steam will also be supplied at each water thermostat. Thus ample provision will be made for a large range of temperatures. Two large direct current electrical generators will supply D. C. current. Since they can be connected in parallel, about 60 amperes, D. C. can be obtained at 110 volts. Special provision has been made for accurate conductivity determinations and for work in a dark room. A recitation room is specially equipped for physical chemistry.

Because of the prominent location of these laboratories they will be a source of pride to each alumnus and friend of West Virginia, who has the opportunity to inspect the building. In order to attain an influence which will be recognized throughout the United States and other countries, research work must be continually in progress and the results published. How much

research is done depends on the number of good research students who can be retained for graduate work in physical chemistry. Enlarge the Chemistry library to a proportion comparable with the other State Universities, and make it possible to retain the good men and women as graduate students by offering the Ph. D. degree for advanced research work. Then in a few years West Virginia University will be noted for Chemistry as well as for athletics. At the same time the other Departments of the University will, if given a chance, enlarge their influence and usefulness because sons and daughters of West Virginia will be making original contributions to the world's store of knowledge. They do it now but they must go elsewhere to make them, and so other states get the credit and most of the benefit.

GLASS

By HUBERT HILL

The manufacture of glass is one of the oldest of industries. Thirty centuries ago the Egyptians were skilled in the art of glass making, and the great European museums of today exhibit specimens of ancient glass in the forms of beads, charms and vases whose beautiful coloring is a marvel and is today unsurpassed. Through the ensuing centuries this industry migrated with civilization and in turn each of the centers of civilization became the center of the glass industry—Egypt, Byzantium, Greece, Rome, Central Europe and at last America.

Glass is made by fusing together sand, lime or lead oxide, and an alkali which may be soda or potash or both. In addition to these three principal ingredients, there are usually included small amounts of other substances in order to impart a color or to give a particular physical property to the glass. Some of these incidental ingredients are oxides of Aluminum, Antimony, Arsenic, Boron, Chromium, Cobalt, Copper, Manganese, Nickel and Zinc; minerals such as Cryolite, Feldspar, Fluorspar, Kaolin; and chemical compounds such as Sodium or Potassium nitrate, Salt Cake, Sodium Selenite. Since sand is the chief constituent of glass comprising as it does from 60 to 80 per cent of all glass and since gas is the ideal and, at present, only practical fuel, it follows that those localities favored by natural deposits of high grade glass sands and natural gas, or coal which may be converted into producer gas or by-product gas, are logically the great glass centers.

The first glass factory in the United States was built at Jamestown, Virginia, in 1608 but it was doomed to an early failure. Bottles were made in Salem, Mass., in 1622. Albert Gallatin established the first glass plant in Western Pennsylvania in 1787, and by the time of the Civil War glass plants were numerous in favorable localities. No period of time records so many revolutionary changes and advances as the last half century.

The glass industry is one of the major industries of what is commonly called the Pittsburgh District. The natural resources of a district determine the class of manufacturing of that district and so it has fallen to the lot of Western Pennsylvania, West

Virginia and Ohio to produce glass because of the presence of natural gas, coal, sand and limestone. Natural gas with its high calorific value is the ideal fuel for the melting of the ingredients of glass and with the opening of the West Virginia fields glass plants were located in these fields. Fuel was the drawing card and in many cases local sands and limestones were not used at first. When the gas fields of West Virginia are depleted, local coal will be used for the production of producer gas and by-product gas and this state will continue to compete with other localities in the production of glass. Producer gas with its low calorific value is inferior to natural gas. A much longer time is required to heat a pot on a new fire with producer gas, but once the desired temperature has been reached there is no difficulty in maintaining this temperature. Both crude oil and electricity have been used in the manufacture of glass but their cost is prohibitive. Gas from coal seems to be the one fuel upon which the future of the glass industry rests.

The following statement from a paper by W. A. Hamor, Asst. Director Mellon Institute, J. I. E. C. for September, 1922, gives a good idea of what has been done in the Pittsburgh District in glass technology.

"The first regenerative pot furnace was built at the O'Hara Glass Works in 1865 by J. B. Lyon; natural gas was first used in melting glass in 1882 by the Bradford Window Glass Company and two years later it was employed for melting flint glass at Wellsburg, West Virginia; the prepressed blank was invented by Philip Arbogast, of Pittsburgh in 1882, and marked a fundamental step in the evolution of the automatic bottle machine; Selenium ruby glass was first manufactured by Nicholas Kopp of Pittsburgh in 1894; flint glass was first melted in a tank furnace by C. H. Runyon, in a factory of the Keystone Glass Company, Rochester, Pennsylvania; machine drawn window glass was first made in 1900 in the Arnold, Pennsylvania, plant of the American Window Glass Company, by the machine invented by J. J. Lubbers; and machine drawn sheet glass was first produced successfully at Franklin, Pennsylvania, by the invention of I. W. Colburn (now the Libby-Owens Sheet glass machine)."

The modern methods of glass manufacture are far in advance of the methods of even a few years ago. The use of moulds was common with the Egyptians and the material used for moulds was clay. The Germans and Austrians used moulds made of

hard wood which they kept wet to prevent burning. The inside of these moulds became more and more charred and the interesting discovery was made that the charred surface acted as an excellent polishing tool when the blown article was rotated in the mould. This method of polishing likewise obliterated the unsightly seam always produced in an article blown in a mould. When iron moulds were invented they were smeared on the inside with a charcoal paste in order to obtain wooden mould efficiency in the more durable and more symmetrical iron moulds. These moulds were used by workmen who blew the glass by lung power. The glass article so blown is ready for annealing. This is accomplished by passing the article through a long oven where the temperature slowly rises almost to the melting point of the glass and then slowly falls to room temperature as the train of articles passes through the oven. Proper annealing is one of the most important steps in the manufacture of glass. Automatic machines have replaced the slower hand blowing. Today window glass is pulled from the tank in great cylinders three feet in diameter and forty feet long, each weighing over three hundred pounds. A later development in the manufacture of window glass is to pull out a continuous flat sheet eighty-four inches wide. Automatic bottle machines of ten or fifteen arms operated by a minimum of labor deliver thirty or more bottles per minute.

The field for future research in glass technology is wide and varied. The engineer, the physicist and the chemist each has his problems to solve and these problems can best be worked out by a close co-operation. Perfection has not yet been reached in any phase of the industry. One of the most promising fields for research is the development of a better refractory for use in the building of the tank so that heat losses may be cut down. Roughly speaking the efficiency of a glass furnace is about 10 per cent. The heat lost by radiation is about 70 per cent and the loss up the stack about 20 per cent. Better insulation can easily be obtained but the clay blocks will not stand the heat. The blocks are already at about the limit of their endurance, so before a saving in wasted heat energy can be effected, a more resistant refractory must be developed.

Great advances have been made in the last few years in the annealing of glass, especially during the war period when for the first time high grade optical glass was made in this country

on any appreciable scale. Previous to the war almost all of the high grade optical glass was made in Europe. Annealing is a process of gradually cooling glass in order to eliminate internal strain. Breakage originates from the inside. When a blown article is cooled quickly the outside becomes rigid while the inside is yet in a semi-plastic state and the glass is under a severe strain. Slow cooling or annealing permits the glass to solidify without this internal strain. Recently Adams and Williamson have made a comprehensive study of the problem of annealing a borosilicate crown glass, the most difficult of all glasses to anneal, and have discovered that uniform slow cooling was not all that was necessary in annealing glass but that there are critical stages in the process where particular slow cooling is necessary and there are other stages where slow cooling is unnecessary and time may be saved by rapidly dropping the temperature. This fact when applied to a factory with a large output will speed the process, thus giving a more rapid turnover and thereby reducing cost. This principle was employed in the annealing of a 40 inch reflector disk recently manufactured in this country.

A close study of the relation of physical properties of glass to chemical composition is a fertile field for further investigation. The introduction of small amounts of incidental elements into the batch will impart a particular physical characteristic to the glass. Variations in the composition of the batch will likewise vary the character of the glass. Variations are obtained by substituting Barium or Strontium or Zinc for Calcium or Lead, or by replacing Sodium by Potassium. A glass is now made which while opaque to visible radiation transmits the infra-red; and another while opaque to visible radiation, transmits the ultra violet.

Considerable light has been thrown on the nature of glass in the successful attempt to make a glass through which an iron wire could be sealed. In order to make a glass into which a wire could be sealed it was thought that it would only be necessary to make a glass having the same coefficient of expansion as the metal of the wire. The coefficient of expansion of copper is about twice that of platinum and inasmuch as glasses are made that will make a perfect seal with both copper and platinum no difficulty was anticipated in making a glass that would make a perfect seal with iron whose coefficient of expansion is about midway between copper and platinum. When a glass with the

correct coefficient of expansion to seal with iron was made it was found that the seal between this glass and an iron wire was imperfect. Investigation of the failure has developed the well founded idea that the seals with the soft metal copper and platinum are perfect because the glass can pull and deform them but in the case of the iron seal the glass broke under the strain of pulling the iron. In order to make a seal with an iron wire a glass was made having a greater plasticity over a very long range of temperature and the problem has been solved. The glass could flow and follow the metal and thus relieve strain.

Modern lighting methods are the result of the perfection of opaque glasses whereby the rays of light from the incandescent filament are reflected and refracted but only very slightly absorbed. The beautiful opaque bowls and globes so common today are made by introducing into the batch a material which separates on cooling and since it possesses optical properties different from those of the glass the result is a glass possessing great refractive power. Many substances are used to produce this opaque glass but those in most common use are talc, phosphates, fluorides, and sometimes oxides of tin, titanium or zirconium. The early types of opaque glasses were made by introducing into the tank finely divided material and keeping the temperature as low as possible so that the material would not melt. This method introduced much air and each air bubble adds to the refractive power of the glass. Phosphate opaque glass contains about 10 per cent bone ash. This glass is perfectly clear and transparent in the molten condition and only becomes opaque or "strikes" as the glass solidifies. Various degrees of opacity from a slight opalescence to perfect opaqueness are produced by increasing the amount of bone ash. Cryolite, a natural double fluoride of Sodium and Aluminum is used in place of bone ash but it has the disadvantage of being costly, so investigation has shown that a mixture of fluorspar and aluminum oxide is now used with good success.

The manufacture of iridescent glass is a very old art. The commonest method of producing this iridescence is to subject the hot glass to the fumes of metallic salts. This process is carried out in a furnace of particular design. The heating must be slow and uniform. A lead glass shows better results than a glass high in silica.

Both salt cake (sodium sulphate) and soda ash (sodium carbonate) are used to supply the necessary soda content of glass. The choice of material is largely based upon comparative cost of the two materials. From the standpoint of cost only the material supplying the most soda per dollar would be the logical product but experience has shown that the batch in which all salt cake and no soda is used is more destructive to the tank than one in which the soda is derived from soda ash. In addition more fuel is required to melt an all salt cake batch but an all soda ash batch produces more scum. As a result of these facts a mixture of salt cake and soda ash is frequently used. It is desirable to keep the sulphur content of the finished glass down to a minimum. A sulphur content of over .50 per cent calculated as sulphur trioxide is undesirable. The reducing gases of the fuel and a little coal mixed with the batch remove most of the sulphur and it goes up the stack as sulphur dioxide.

Recently selenium has replaced gold or copper in the manufacture of red glass. Many metallic oxides are used to impart a particular color to the glass. It has generally been considered that the color is produced by the finely divided metal distributed through the glass, yet by special processes of chilling certain glasses containing metallic oxides a colorless glass is produced. When these same glasses are again heated to the melting point and slowly cooled, the color develops. It has been suggested on purely speculative grounds that the size of the metallic particles in the colorless glass are so small as to have no effect on light rays—hence the absence of color. A second heating and slow cooling permits aggregations of these and with the increase in size of the light intercepting particles color develops. Nickle oxide imparts to the glass a color which varies from brown to blue depending upon whether the glass is a lime soda or a lime potash or a lime lithia glass. When the silica is increased and the alkali decreased giving a more acid glass the variations in color are even more pronounced than in the more basic glasses. A vast field is therefore open for research work on the cause and control of color in glass. Iron salts impart a greenish color to glass and the glass chemist is ever on the alert to determine the iron content of all glass making material. For the better grade of glass the permissible iron content is very low. Some fine glass sands have as little as .03 per cent iron oxide. For bottles and window glass the iron content of the sand may run many times

.03 per cent. The greenish color may be visually neutralized by the addition of a manganese compound to the glass batch. There is an advantage in correcting this greenish color in the case of bottles but none in the case of window glass. The green color is not removed by manganese but only counteracted by another color imparted by the manganese and the corrected glass passes actually less light than an uncorrected one. A window glass whose color appears quite green when viewed on edge or through many thicknesses appears colorless when viewed through a single thickness.

The glass industry is one of the big industries of the United States and particularly of northern West Virginia, Western Pennsylvania and Ohio. The following data from the United States Census report give a good idea of the importance of the industry:

	1921	1919
Number of Establishments.....	328	371
Persons Engaged.....	59,705	83,656
Pay Roll.....	\$ 79,852,000	\$100,891,000
Cost of Material.....	86,883,000	90,780,000
Value of Products.....	212,593,000	261,884,000
Value added by Manufacture... 125,710,000	171,104,000	

Of the \$212,593,000 of manufactured products, the following distribution is cited by the census:

	1921
Window Glass.....	\$ 23,543,000
Obscured Glass.....	2,547,000
Plate Glass:	
Polished.....	37,261,000
Rough.....	107,000
Wire Glass:	
Polished.....	1,512,000
Rough.....	1,804,000
Miscellaneous Building Glass.....	1,694,000
Pressed and Blown.....	57,375,000
Bottles and Jars.....	83,692,000
All other Products.....	3,058,000
Total.....	\$212,593,000

Of the 328 establishments reported in 1921 the following geographical distribution is cited: 89 are located in Pennsylvania; 72 in West Virginia; 37 in Ohio; 30 in Indiana; 19 in New York; 15 in Oklahoma; 14 in New Jersey; 11 in Illinois; 9 in California; 6 in Maryland; 4 each in Arkansas and Kansas; 3 each in Missouri and Virginia; 2 each in Louisiana, Texas and Wisconsin; 1 each in Massachusetts, Michigan, Rhode Island, South Carolina, Tennessee, and Wyoming. Pennsylvania produced 30.7 per cent of the total.

THE ESTIMATION OF IMPURITIES IN BATTERY ACIDS

By LILY BELL SEFTON DEATRICK

I. INTRODUCTION

The work represented by this paper appears here by courtesy of the Bureau of Standards. During the latter part of the war a piece of work was started to determine the maximum amount of the various common impurities which might be present in battery acid without affecting materially the performance or life of the battery. A preliminary examination of the methods used by various manufacturers, both of sulfuric acid and of batteries showed a surprising lack of uniformity and quantitative accuracy, so it was necessary to work out methods for the determination of such common impurities as nitrogen compounds, antimony, arsenic, calcium, chlorides, copper, iron, manganese, and platinum, before anything further was done on the original problem.

Practical reasons render it necessary that the methods selected should combine reliability, accuracy and sensitiveness with speed and simplicity, and should not depend upon preliminary evaporation or neutralization which tend to produce loss by contamination. It is also important that the reagents selected should not be affected by other impurities likely to be present in battery acid. These restrictions make colorimetric methods in most cases alone applicable. A comparative study was made of methods with the purpose (1) of pointing out the methods proved to be most reliable and (2) suggesting the best conditions for using them.

Fresh battery acid—that is, a solution of sulfuric acid of specific gravity 1.28—and acid which had been used in batteries for some time showed under the same given set of conditions appreciable differences in the depths of color given by the various reagents studied. These differences vary in amount and direction with the reagents but are great enough in every case to make it advisable for the standards to be made up with used electrolyte (free from the impurity under examination) when the sample of acid under examination has itself been used in a battery.

The impurities most likely to interfere with the detection of other impurities are nitrates, nitrites, arsenic, antimony,

chlorides, copper and iron. Standard solutions of these substances were made up in a sulfuric acid solution of 1.28 specific gravity and used in all experiments described in this paper. Blank tests were run with each determination. After experimenting with various types of colorimeters, it was found that best results were obtained by using Nessler tubes provided with close-fitting jackets of black paper and observing the colors reflected from a white surface.

II. METHODS

1. **AMMONIA.** Neutralize 2 cc. of the sample with sodium hydroxide, filter, if necessary, to remove iron, and nesslerize directly. This gives a rough idea of the amount of ammonia present and standard solutions are made up according to the findings of this preliminary examination.

Distill a 20 cc. sample with sodium hydroxide and nesslerize aliquot parts of the distillate. Sensitiveness: 1 part in 20,000,000 (0.000005 per cent). None of the common impurities in battery acid interfere with this method.

2. **NITRITES.** Nitrites are oxidized to nitrates in dilute sulfuric acid and it was found that the rate of oxidation increased with the dilution of the acids. Nitrites in a 1.28 sulfuric acid solution are all changed to nitrates at the end of three days. It is not necessary, then, in most cases, to test for nitrites. In case such an examination is desired, the following method is recommended:*

Add three drops of a dimethylaniline hydrochloride solution to 25 cc. of the battery acid and allow to stand for from 10 to 30 minutes. If nitrites are present a yellow color appears. Compare with standards similarly and simultaneously treated.

Sensitiveness: 1 part in 1,000,000. (0.0001 per cent). The method is unaffected by the presence of 0.005 to 0.01 per cent of other impurities.

3. **NITRATES.** The diphenylamine method so frequently used for the determination of nitrates is useless. To 10 cc. of the sample add enough pure sulfuric acid to make the specific gravity of the mixture 1.65—1.70, cool to room temperature, add 2 cc. of a freshly prepared solution of brucine in concentrated sulfuric acid. Compare with standards when the initial rose-red color has changed to sulfur-yellow and before it has changed to the final golden-yellow.

*Technologic Paper of Bur. of Standards, No. 149, 1920.

Sensitiveness: One part in 5,000,000; (0.00002 per cent). The method is unaffected by the presence of 0.005 to 0.025 per cent of other ordinary impurities. In solutions of 1.70 specific gravity (or below) nitrites respond to this treatment to about the same extent as nitrates.

4. **ANTIMONY.** If a preliminary examination of the sample with hydrogen sulfide shows less than one part of antimony per 100,000, the antimony may be determined by passing hydrogen sulfide thru the solution for 30—60 seconds and comparing the color formed with that formed in standard solutions similarly and simultaneously treated. If more than one part per 100,000 is present—and it frequently is—the following modification is recommended:

Add 2 cc. of a five per cent solution of gum acacia to 10 cc. of the test solution. Pass hydrogen sulfide thru the mixture for 15—30 seconds and compare the color with that developed in standards similarly modified. 2 cc. of a five per cent solution of gum acacia will hold as much as 2 milligrams of antimony (per 10 cc. sample) in a colloidal state.

Sensitiveness: 1 part per 1,000,000 (0.0001 per cent). Copper interferes with the test. Arsenic does also, but since arsenic and antimony are equally deleterious to a battery, the two are frequently estimated together.

5. **ARSENIC.** Proceed as with antimony. Twice as much of the gum acacia solution is needed to hold the same amount of arsenic sulfide in colloidal form and the sensitiveness of the method is not so great with arsenic. (One part in 500,000—0.0002 per cent).

6. **CALCIUM.** If more than one part of calcium in 10,000 is present, neutralize a 25 cc. sample with ammonium hydroxide, add a saturated solution of ammonium oxalate and allow to stand on the steam bath over night. Filter thru asbestos, dissolve in sulfuric acid and titrate with a very dilute solution of potassium permanganate.

If less than one part of calcium per 10,000 is present it will be necessary to use a turbidity test. Treat as directed with ammonium hydroxide and ammonium oxalate, allow to stand over night, shake thoroly and compare the amount of turbidity with that formed in standard samples.

Sensitiveness: 1 part in 50,000 (0.002 per cent).

6. **CHLORINE.** Add 5 cc. of a five per cent solution of silver nitrate to 25 cc. of the sample. A light opalescence indicates chlorides. Allow to stand three minutes before comparing with the standards.

Sensitiveness: 1 part in 1,000,000 (0.0001 per cent). Bromides and Iodides may interfere. Any possible interference with the sulfuric acid itself may be controlled by blanks.

7. **COPPER.** If a sample contains no iron, the following method is used: To a 20 cc. sample add ammonium acetate crystals till no more dissolve. Filter and to the filtrate add 2 drops of a 2 per cent solution of potassium ferrocyanide. Allow the color to develop for five minutes before comparing with standards.

If iron is present, heat with a few drops of nitric acid, add a slight excess of ammonium hydroxide, filter, neutralize with acetic acid, cool and add 2 drops of the potassium ferrocyanide solution.

Sensitiveness: 1 part in 1,000,000 (0.0001 per cent). None of the common impurities interfere. Copper is very seldom found in battery acid.

8. **IRON.** This method is based on the Stokes-Cain Paper published in Bulletin Bureau of Standards 3, p. 115; 1907. It was found that the use of the amylic absorbent recommended in that paper was unnecessary for the determination of iron present in battery acid.

To a sample (diluted if amount of iron present is considerable) add a few milligrams of ammonium persulfate and shake. Add five cc. of the sulfocyanic acid reagent (see paper referred to above for full details of the preparation of this reagent). Compare with standards immediately after the addition of the reagent.

Sensitiveness: 1 part in 50,000,000 (0.000002 per cent). None of the common impurities interfere.

9. **MANGANESE.** Manganese is most injurious to batteries. The method used for its determination is based on W. Blum's paper on the use of Sodium bismuthate in Acid solution.*

Keep all test solutions, standard solutions and reagents at a temperature of 15°C. thruout the operations. To 25 cc. of the test sample, add 0.5 g. of sodium bismuthate and 25cc. of nitric acid solution. Shake for 1—2 minutes and filter thru asbestos. Comparisons with standard solutions must be made within three minutes after treatment with the reagent. Standards

*Am. Chem. Jour. Vol. 34, p. 1379.

made by dissolving potassium permanganate crystals in water are useless—they must be made from manganese solutions treated in the same manner as the test solution.

Sensitiveness: 1 part in 2,000,000 (0.000005 per cent). None of the common impurities interfere.

10. PLATINUM. Direct treatment with a potassium iodide solution—a method very often recommended is worth less than nothing. Treatment with stannous chloride solution—another industrial favorite—will show the absence of platinum (in case no color develops). If a color appears it may or may not be due to platinum. To ascertain this point, proceed as follows:

Evaporate a 25 cc. sample to dryness taking up several times with nitric acid. Dissolve the final residue in aqua regia, neutralize with ammonium hydroxide and acidify with formic acid digesting for 24—48 hours on the steam bath. If platinum is present it will appear as a flocculent black precipitate which may, if desired, be filtered off and estimated colorimetrically with potassium iodide.

Sensitiveness: 1 part per million (0.0001 per cent). None of the common impurities interfere.

NOTE—The figures given for the sensitiveness of these methods are based upon test solution made up with “fresh” acid. Solutions of “used” acid are not quite so sensitive.

III. SUMMARY

1. The methods described in this paper have been selected from more than five hundred methods mentioned in literature and have been modified in such a way as to give, under the conditions defined, reliable results for estimating the amounts of common impurities in battery acid.

2. The methods recommended do not involve a complicated procedure nor require elaborate apparatus. They may, therefore, be used for quantitative determinations in an ordinary laboratory.

3. Nitrites are not likely to be found in used battery acid since all nitrites are quickly changed to nitrates in a dilute sulfuric acid medium.

4. Ammonia is determined by nesslerization; nitrates by a modified “brucine” test; nitrites by dimethylaniline.

5. Antimony and arsenic are determined by using hydrogen sulfide in the presence of gum arabic.

6. Turbibimetric tests are used in the estimation of calcium (as an oxalate) and chlorides (as silver chloride).

7. Copper and iron are determined colorimetrically by the use of ferrocyanide and sulfocyanide respectively; manganese by oxidizing with sodium bismuthate to permanganate.

8. Any platinum present is reduced to the metallic state by formic acid and determined colorimetrically by the use of potassium iodide.

IV. ACKNOWLEDGEMENTS

I desire to acknowledge by indebtedness to Mr. G. W. Vinal and to Dr. H. D. Holler for their helpful suggestions during the progress of this work.

A STUDY OF THE ACTION OF CHLOROMETHYLBENZYL ETHER ON SALTS OF ORGANIC ACIDS¹

By FRIEND E. CLARK

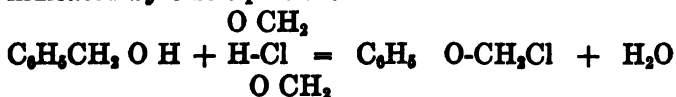
Primary alcohols react with formic aldehydes in the presence of hydrogen chloride to form ethers which are like ordinary ethers in composition, except that they have one hydrogen replaced by chlorine. Such ethers are called chloro ethers. A review of the literature has already been published.² Other alkyl chloro ethers have been studied in connection with these researches in this laboratory. The results of this work have not yet been published. The general course of the reactions is similar to that found by Clark, Cox and Mack and can be represented by the general formula

$$R \cdot \overset{\text{O}}{\underset{\text{CH}_3}{\text{C}}} \text{OH} + \text{H-Cl} \rightarrow R\text{-CH}_2\text{-O-CH}_2\text{Cl} + \text{H}_2\text{O}$$

where R represents either H as in methyl alcohol or alkyl radicals as in the homologues of methyl alcohol.

The use of the chloro ethers as synthetic agents has long been recognized. Several products of this nature received attention as war gases. The idea now is to show how the reactions can be carried to the aryl alcohols, and from one of these compounds, chloromethylbenzyl ether, to prepare certain esters in accordance with the equation given above, except that R represents an aryl group instead of an alkyl radical.

Preparation of Chloromethylbenzyl Ether—50 grams of benzyl alcohol and 50 grams of 40% formic aldehyde were placed in a tall Drexel bottle which was surrounded by ice and water. Hydrogen chloride was passed into the mixture until no further absorption could be noted. In a short time the contents of the bottle separate into two layers, the bottom layer being the chloro ether which gradually becomes colored light brown. The reaction is complete after five hours of this treatment and proceeds as indicated by this equation.



1. With C. T. Gayley and W. H. Moran.

2. Clark, Cox and Mack, *Amer. Chem. Journal*, 39, 713 (1917); Clark and Cox, Centre College; Clark and Mack, W. V. U.

The reaction is decidedly exothermic and a cooling bath of some kind is necessary. A bath of water kept at room temperature will give good results, but it is recommended that an ice bath be used. The chloro ether is separated from the saturated hydrochloric acid and dried over fused calcium chloride. Repeated fractionations gave a product boiling from 216°—218°.

Chloromethylbenzyl ether is an isomer of chlorobenzylmethyl ether but presents properties unlike those of the latter compound. The product which was concerned in this research hydrolyzes easily, reverting to the initial compounds, namely, formic aldehyde and benzyl alcohol; whereas its isomer undergoes no similar change. The chloromethylbenzyl ether which was prepared and used for the syntheses as herein described, is a clear, oily liquid, possessing a pungent ethereal odor. Its molecular weight was found to be 155 (theory, 156.6); density of the liquid, D_0° -1.1523, D_{18}° -1.353, D_{25}° -1.1289.

METHOXYBENZYL FORMATE—Chloromethylbenzyl ether was added to an excess of the calculated amount of lead formate. The mixture refluxed on an oil bath, for three hours, and later subjected to fractional distillation, the fraction giving the best results boiling at 232-233°. The molecular weight as determined is 164 (theory 166). The density of the liquid is D_0° -1.1365, D_{18}° -1.1200, D_{25}° -1.1135. On analysis the following data were obtained:

	Carbon	Hydrogen
	64.94%	6.35%
Theory for $C_9H_{10}O_3$	64.04%	6.08%

These results are not very close for the hydrogen content. The carbon results leave no doubt as to the composition of the compound. Its decomposition on hydrolysis is in keeping with established facts as regards the ether-ester bodies. Its structural formula is $C_6H_5-CH_2-O-CH_2-OOC.H$. It is a clear liquid with a sharp characteristic ester-like odor.

METHOXYBENZYL ACETATE—This product was prepared both by treatment with lead acetate and anhydrous sodium acetate. The proceeding being exactly like that described with the previous compound. A product was not secured of greater purity than that indicated by the fraction, 245°-249°. Paraformaldehyde appeared in the condenser tube, indicating decomposition.

The product gave a molecular weight 177 (theory 180). Density D_0° -1.1050, D_{18}° -1.0887 D_{25}° -1.0831. It also is a colorless liquid, with a pungent odor, somewhat resembling mustard gas. Analytical data on the carbon and hydrogen were:

	Carbon	Hydrogen
	66.32%	6.69%
Theory for $C_{10}H_{11}O_3$	66.63%	6.72%

These results point to the compounds as being like others of the series, an ether-ester body, $C_6H_5 \text{ C } H_2\text{-O-CH}_2\text{. O. O. C. CH}_3$.

METHOXYMETHYL PROPIONATE—The ester was prepared in the same manner as the acetate. The same difficulties were encountered in obtaining a uniform boiling product, the best one boiling 256-260°. Density determinations gave D_0° -1.0826; D_{18}° -1.0665; D_{25}° -1.0602. Carbon and hydrogen determinations gave

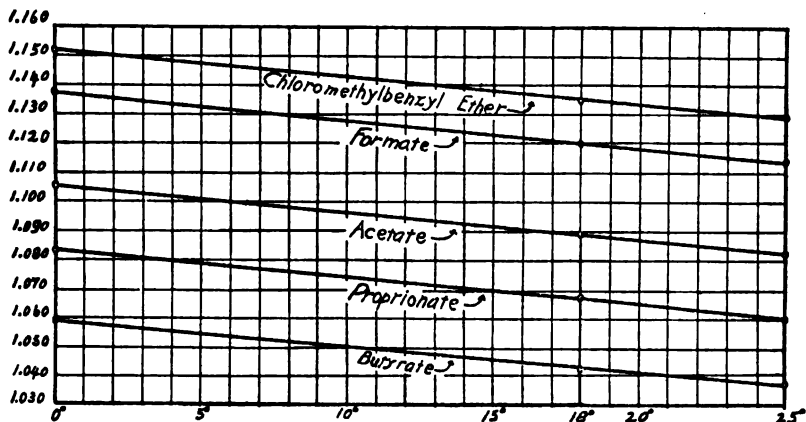
	Carbon	Hydrogen
	69.24%	7.73%
Theory for $C_{12}H_{16}O_3$	69.19%	7.75%

Its structural formula is $C_6H_5CH_2\text{-O-CH}_2\text{-OOC } C_2H_5$.

METHOXYBENZYL BUTYRATE—The preparation of this compound was carried forward in the same manner as the others, but greater decomposition was always noted when the product was distilled. The decomposition seemed to increase with the increase in molecular weight, which allows the statement that the stability of each of the compounds is inversely proportionate to the molecular weight. The best fraction boiled 268°-272°. Density, D_0° -1.0587; D_{18}° -1.0433; D_{25}° -1.0374. There are no data for the carbon and hydrogen determinations of the compounds. The colorless, pleasant smelling, oily liquid probably has the composition as shown by the formula, $C_6H_5\text{. CH}_2\text{-O-CH}_2\text{-O.OC } C_3H_7$.

We have shown how aryl primary alcohols react in gram molecular quantities with gram molecular quantities of formic aldehyde and hydrogen chloride; and that these chloro-ethers react with salts of organic acids to produce compounds which are both ethers and esters. A striking contrast to reactions of aryl primary alcohols, formic aldehydes and hydrogen chlorides is that of phenol and formic aldehyde in the presence of various

catalytic agents. Very complex reactions take place, giving rise to various polymeric compounds, which are marketed under certain trade names as Bakelite, Redmanol, etc. The effect of increased molecular weights on the density of the compounds is here illustrated.



In the future it is planned to continue these syntheses, using aryl aldehydes and alkyl alcohols.

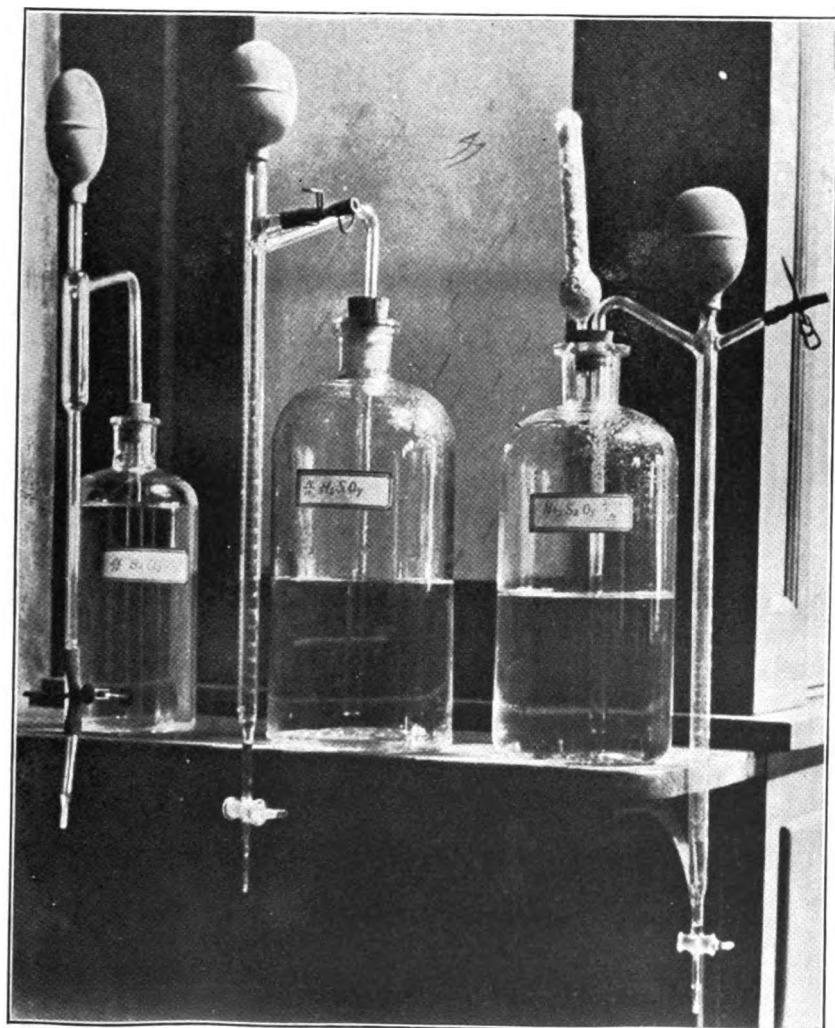
A REAGENT BOTTLE SIPHON

By C. A. JACOBSON

During some chemical research work that the writer was carrying on prior to coming to West Virginia he frequently had occasion to use a siphon for withdrawing reagents from bottles, and for removing supernatant liquids held over light flocculent precipitates. The siphons then obtainable were entirely unsuitable and a pipette-siphon, such as is shown in the smallest bottle in the figure was developed. This siphon was constructed by attaching a side tube to the bulb of the pipette and bending the other end down as shown, and cutting it a little shorter than the lower end of the pipette. The upper end of the pipette is provided with a rubber bulb by means of which the siphon is filled. The lower arm of the siphon is provided with a rubber tube and pinch clamp. When the siphon has been filled with the liquid as explained and the clamp is opened the liquid siphons over. The siphoning may be carried on at different rates of speed by regulating the size of the opening in the rubber tube by means of the clamp.

The two larger siphons shown in the same cut represent a later modification of the apparatus. Instead of the pipette arm these two are provided with burettes which are calibrated to 25 cubic centimeters in 1/10 cc. These siphons are filled in the same manner as the one described above, but in the improved form the burettes are closed at their lower ends by means of glass stopcocks instead of pinch clamps. They are also provided with small glass side tubes shown on the right, provided with rubber tubes and clamps for breaking the vacuum when it is desired to interrupt either the filling of the burette arm or the siphoning.

This latter form is especially useful where only a measured quantity of some reagent is required and in addition to this, if the reagent would be contaminated by either carbon dioxide, ammonia, or hydrogen sulfide present in the air suitable absorbents may be provided in guard tubes inserted in the bottles as shown.



The advantages of this form of siphon may be summarized as follows:

First: It is a more convenient method of withdrawing a liquid from a bottle especially where the liquid is poisonous or has an offensive vapor.

Second: It offers a convenient method of obtaining a measured quantity of liquid from a bottle without the use of other measuring apparatus.

Third: When measured quantities of liquids are thus easily obtained, it actually reduces the consumption of reagents to about one-half as compared with older methods of blowing or pouring out the reagents, for as is well known, students take about twice as much of a given reagent as necessary for the experiment when there is no convenient way of measuring the amount required.

Fourth: The siphon is simple in construction, inexpensive, and might be used in many other places such as drug stores, soda fountains, botanical, pharmaceutical and zoological laboratories.

A NOVEL CALCULATING MACHINE

By C. A. JACOBSON

Knowing the tremendous usefulness of the Slide Rule and its penetration into nearly every science and industry, and knowing also its limitations, especially as far as accuracy is concerned, I set about to develop a machine* which had all the advantages of the Slide Rule coupled with the same accuracy obtained by a five place logarithmic table.

*Last year, at a meeting of the West Virginia University Scientific Association, I presented this subject, and then published a summary of the discussion in *Chemical Age*, Vol. X, pages 51-52. After that the subject received wide publicity in the daily papers throughout the country. Inquiries about the machine and where it could be purchased came from half a dozen or more states and even from as far away as the government laboratories in Melbourne, Australia. Unfortunately no manufacturer has been obtained who was able and willing to go into the business of producing these machines for the trade, and the prospects in this direction are not yet good. At the time I had no way of showing the operation of the machine except by the patent-paper drawings, which did not set it forth very clearly.

To those familiar with the Slide Rule it is clear that when two logarithmic scales, equal and opposite, are placed in juxtaposition, they provide a means for multiplying or dividing numbers, which is the same as adding or subtracting the logarithms of those numbers. Both scales of the Slide Rule have been divided into logarithmic distances instead of actual distances so that, for example, if we add the numbers 2 and 8 on the Slide Rule scale we obtain 16 instead of 10 and if we subtract 2 from 8 we get 4 instead of 6. This means that we are adding or subtracting logarithmic and not actual distances.

The actual ruled distance on the ordinary Slide Rule is about ten inches, and this distance has been divided into the logarithmic distances from 1 to 10. On my machine these same logarithmic distances have been spread over an actual distance of 328 feet (10,000 centimeters to be exact), making this machine about 400 times more accurate than the Slide Rule.

It would obviously be impossible to operate a straight rule 328 feet long; consequently a scale of this length has been ruled in the form of a spiral band or helix on each of two mechanically operated drums, which are only about a foot in diameter. The calibrated spiral scale on one of the drums serves as the "slide" and the other as the co-ordinated "rule." The accompanying cut shows the calculating machine in perspective.

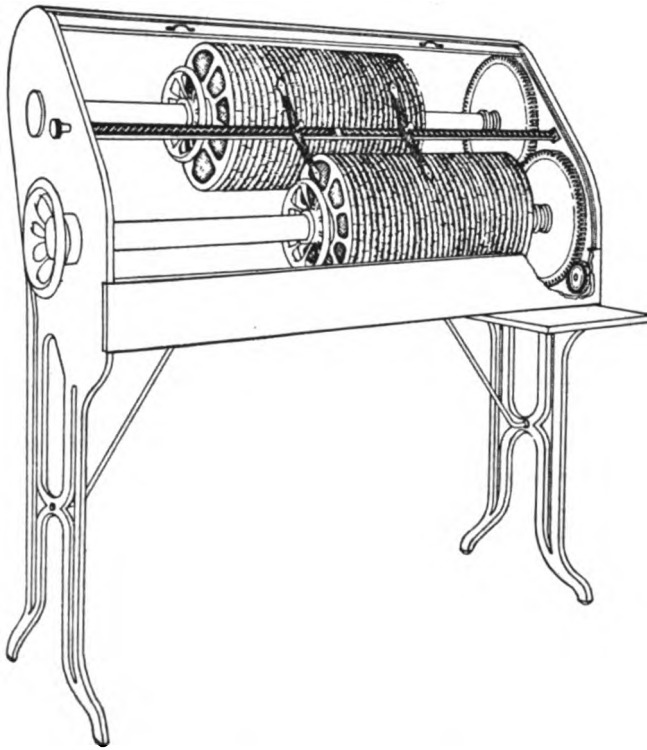


Fig. 1: A NOVEL CALCULATING MACHINE

This machine is a mechanical device that multiplies, divides, extracts roots, raises numbers to any power, gives at a glance twelve different functions of any angle which may be brought directly into computations, as well as computes the analyses of over 3,000 chemical determinations, and may equally well be employed in surveying, astronomy, mathematics, physics, engineering, banking, or any phase of human knowledge where factors can enter into calculations.

The machine is composed of two movable drums mounted upon axes. These are controlled by a geared mechanism, in such a way that the machine will give the answer to some of the most difficult computations in a few seconds of time, by three or four slight movements of the drums, and the answer will be correct to six decimal places.

These drums or cylinders are movable on the shafts, but may be clamped to the shafts at any desired point by means of brake-shoes operated from the right hand ends of the drums by thumb screws. When so clamped the drums may be turned in unison by a geared mechanism and the fine adjustments made by a micrometer screw engaging one of the larger gear wheels. In this way the relative position, with respect to the index, of two points on the scales will not be altered when the drums are rotated, for after the drums have made a complete revolution, the two points will come into coincidence with one another again. Any given number on one scale may be brought into coincidence with any other number on the opposite scale, by means of a celluloid-headed duplex pointer moving in a channelled bar or guideway, located equi-distant between the drums, and operated by a thumb screw. There are two of these pointers, one operated from each end of the machine.

Various other mathematical functions could be ruled on these drums, as well as the printing of hundreds of chemical formulas, symbols, characters, etc., representing numerical values entering into computations, for there is a distance of 328 feet upon which these may be spread out.

EXAMPLES OF CALCULATIONS

As examples of carrying out calculations on this machine let us say that we want to multiply 8467 by 378. Set the right pointer on the lower drum at 8467, which is shown in large divisions on the scale. Turn the upper drum so that the other

end of this pointer shows 378, and clamp the drums on the shafts as already described. The shafts and drums are then rotated in unison until the left index (or end of the scale) of the upper drum appears, when the left pointer is adjusted so that its hair line falls upon this index. The hair line of the lower end of this pointer gives the reading 320053. Division is just as simple as this. The only difference is that the index of one scale is set on the dividend, and the other pointer on the divisor, when the quotient is read from the other end of this pointer.

If for example, we are standardizing a sulfuric acid solution, and have precipitated a given volume of it with barium chloride and have weighed the resulting barium sulfate. Set the right pointer to correspond with this weight on the lower drum, and the upper end on the number 4200, which is the factor for barium sulfate to sulfuric acid, found on the factor board. The upper end of the left pointer is placed upon the index, when the lower end of this pointer shows the weight of sulfuric acid desired. To arrive at this result there have been one setting on the lower drum and two settings on the upper, requiring about twenty seconds of time. The same result could have been attained by setting the pointers on the formulas representing these substances, which are found printed on the scales, in the same manner that the chemists' slide rule operates, but this would involve one more setting of the machine.

To raise a number to a given power, multiply its logarithm, which is the actual distance on the scale from the unity index and is read directly on the drum, by the number of the power. To extract roots, divide the logarithm of the number by the power of the root. For carrying out trigonometric computations the spiral scale on the lower drum is ruled in red ink corresponding to natural sines. The log sines are shown by black lines where a given angle is marked. Cosines and log cosines may be obtained from the opposite index of this drum. Tangents and cotangents are shown by green lines on the lower drum, while secants and cosecants are given by blue lines on the upper drum. These functions are brought into computations in a similar manner to that described above.

This machine no doubt, would have a wide scope of usefulness, and would render a service that is not obtained by any calculating device now available.

CHEMICAL SPELLING

By C. A. JACOBSON

In May, 1922, a new departure in chemical education was tried at the West Virginia University in the form of a chemical spelling match, which was conducted similarly to the old time spelling bee. As far as I know, no chemical spelling match had ever been held before. The results of that match were so encouraging that we concluded to hold another in May, 1923; and after the second annual contest, which was staged last May, we decided that the students derive enough benefit therefrom to justify continuing the contests every year.

A discussion of our first match has been given both in Science and in the News Edition of the Journal of Industrial and Engineering Chemistry, but there are certain developments that might be worth bringing out at this time. The contest as we conducted it last spring was about as follows: Only students who had been studying the first year's course in general inorganic chemistry were eligible. These students were regularly divided into sixteen quiz sections composed of twelve to twenty students and each in charge of an instructor. Two quiz sections were combined into one preliminary spelling group, making eight such groups in all.

On the same evening of the final contest these eight groups met in separate rooms and an instructor, with an assistant, put in charge of each, where the preliminary spelling contests were held. The students were arranged in a row around the room, and the instructor began by pronouncing the name of a chemical substance as for example mercuric thiocyanate, and the student replied by spelling its formula, $\text{Hg}(\text{CNS})_2$. If he failed the same word was not given to the next student in line but another word from the list was pronounced. Each failure to spell a word was recorded by the assistant on a paper containing the names of all contestants in that group. As soon as three failures were recorded against a student he took his seat, and the spelling continued until that number of students remained which represented one out of every ten or fraction of the whole number of contestants in the preliminary. For example, if there were twenty-five to thirty-four in the preliminary, the last three students would become eligible

to the final contest. Four, however, would qualify out of a group of thirty-five.

The names of all the successful contestants in the preliminaries were handed in writing to the three judges at the final contest, which was held in the auditorium immediately following the conclusion of the preliminaries. The final spelling match was managed somewhat differently. Thirty contestants had qualified to this contest, which meant that only about two students from every quiz section participated, and therefore the rivalry between the sections became keen and spirited.

Instead of choosing the winners by spelling until three failures were recorded against each contestant, they were chosen on a percentage basis. Every contestant was given a number which was pinned on and plainly visible from any part of the room. The contestants were then arranged in a row on the stage according to these numbers. A member of the staff pronounced the words as in the preliminaries, but all those who missed their first word remained standing until the first round was completed, in other words, till every contestant had had one trial. Then they took their seats and were given the score 30, which was the same for every one. This first score represented the number of contestants taking the floor at the start. As will be seen from the appended table, eight students went down on the first word given to them. All these were given a score of 30 for the first trial. Six went down on the second round, making a score of 22 each. One went down on the third round, with a score of 16, three on the fourth round with scores of 15 each, and so on until one remained, who received a score of 1. The one with the lowest score therefore, attained the highest rank. The contestants were then taken to the floor and spelled down two more times. These scores were summed up, and the contestant with the lowest score declared the winner.

Both years the winner was presented with a copy of Mellor's Modern Inorganic Chemistry, and the four next in rank received certificates suitable for framing, bearing the names of the first five in the order of rank, together with the names of the Head of the Department and the Registrar, as well as the University seal.

A mimeographed list of about 1200 names and formulas was prepared and distributed to the students in question about three weeks prior to the holding of the contest. The reason for not

giving out this list of words or stressing the spelling match before was to prevent some students from overdoing the matter at the expense of regular work. We did not want it to become, in any sense, a "cramming match."

The chemical formula of a substance may be considered the nucleus around which we gather our information about a substance, and while it is not the all important thing to know, yet more information is epitomized in the formula than in any other expression in chemistry. For that reason the student who knows the formula of a compound certainly has an advantage over the one who does not. Several students this year stated that they were benefitted by the spelling match, for without it they never would have acquired so large a chemical vocabulary.

The chemical departments of several other institutions have expressed an interest in chemical spelling, and at least one other university has given it a trial. Two members of the chemistry department of that institution have expressed themselves as being entirely satisfied with the results of their contest.

If the maximum amount of work is to be gotten out of a student he must be appealed to by means of a prize or in the form of competition. Whereas some students will drag along and barely make a passing grade, yet if they are approached in the manner suggested, they may accomplish wonders. We all know that the memorizing of chemical formulas is not chemistry, but if the students can learn everything else in the course and memorize several hundred formulas besides, they will be decidedly better off. The certificates issued to the five highest in rank are prizes coveted by all, for to be among the five highest when nearly four hundred students compete, is considered as great an honor as a scholarship prize.

The following table will tend to clarify the method we used in choosing the winners. The first column gives the numbers of the contestants and the second their names. The third, fourth, and fifth the score attained in the three trials. The sum of these is the final score and is found in column six, while the last column contains the names of the quiz instructors to which these students report for week-end examinations. It will be seen that the girl having the lowest score, or highest rank, did not get highest in either of the three trials. Her sister, however (No. 8), receiving one first and one second did not even qualify for a certificate as one of the first five. The reason is that she went down on the

first word given on the first round, giving her a score of 30 for that trial, making her final score 33. It required about two hours to spell these thirty students down three times, including all intermissions.

For the spelling contest this year we have no material changes to make except that it might be well to hold the preliminary contests three weeks in advance of the final, in order to give the eligible contestants time to prepare and also to avoid tiring those who participate both in the preliminary and final match. We are also planning to revise the list of names and formulas so as to exclude all those of doubtful composition, as well as to pay more attention to the accepted nomenclature of chemical compounds.

Chemical Spelling was discussed in the Chemical Education section of the American Chemical Society at its recent meeting in Milwaukee. Considerable interest was manifested in the subject and the probability is that several other institutions will give Chemical Spelling a trial next spring. Should it receive extensive adoption throughout the country, a committee of the American Chemical Society should be appointed to unify chemical nomenclature and place it on a more authoritative basis.

TABLE

No.	Names of Contestants	Score in 1st Trial	Score in 2nd Trial	Score in 3d Trial	Final Score	Quiz Instructor
9	Ethel Jones.....	4	8	9	16	C. A. J.
10	H. J. Sigwart.....	2	13	6	21	C. A. J.
8	Anna Lewis.....	22	5	2	29	L. B. S. D.
6	Theodore Cooper....	1	2	26	29	C. D. L. R.
14	Jack Furbess.....	12	13	6	31	S. M.
30	G. E. Teel.....	16	10	6	32	F. E. C.
8	Elsie Jones.....	30	2	1	33	C. A. J.
13	Pearl Hill.....	11	17	6	34	S. M.
23	Hazel Roberts.....	7	10	19	36	G. A.
20	L. K. Herndon.....	11	10	19	40	I. W. S.
24	Lillian Stalnaker....	22	10	9	41	L. B. S. D.
4	J. W. Powell.....	11	4	26	41	C. D. L. R.
15	H. J. Brannon.....	7	13	26	46	E. C. H. D.
5	Russel Stewart.....	3	28	19	50	C. D. L. R.
26	Eleanor Bauer.....	15	17	19	51	L. B. S. D.
19	Frank Johnson.....	15	28	9	52	I. W. S.
22	D. S. Randolph.....	7	28	19	54	G. A.
12	Adele Bigelow.....	11	28	19	58	S. M.
16	J. F. Chapman.....	30	10	19	59	E. C. H. D.
11	C. Anderson.....	15	28	19	62	S. M.
1	W. B. Stuck.....	22	17	26	65	S. M.
17	G. C. Weber.....	22	28	26	76	E. C. H. D.
27	W. Roberts.....	22	28	26	76	L. B. S. D.
28	E. M. Hume.....	22	28	26	76	F. E. C.
25	Amy Flynn.....	30	28	19	77	L. B. S. D.
18	D. I. Thomas.....	30	28	19	77	I. W. S.
29	A. S. Chipley.....	30	17	..	..	M. J.
2	R. W. Wotring.....	30	28	..	..	F. E. C.
7	Carrie Boggs.....	30	..	..	..	C. D. L. R.
21	E. M. Morton.....	30	..	..	..	G. A.

A STUDY OF THE GRADING SYSTEM IN GENERAL CHEMISTRY

By SAMUEL MORRIS

The required standard in any subject is always an important matter, and especially is this true of general chemistry. In the last twenty or twenty-five years many new phases of the subject have been added, particularly along the line of physical chemistry. The questions are often asked, is too much being required of the students? Are our standards too high?

This work was taken up with the idea of getting some information with respect to the justice of the grading system in general chemistry in West Virginia University. A study was made of the grades of 272 freshmen taking general chemistry the first semester of the year 1922-23. No upper classmen were included because no intelligence test was available for them. A comparison of the chemistry grades of the students with their intelligence scores, it was thought, would bring out many interesting and important facts.

The average intelligence score for this group of 272 students was 81.4 which is almost exactly that of all the students of this university and of the other universities of the country. The students were divided into four equal sections according to their intelligence scores, and the average of each section, as well as the corresponding average chemistry grade was determined, along with the percentage passing and failing the course. Using the nearest whole numbers, the results are as follows:

	Average Intelligence Score	Average Chemistry Grade	Passed (Grade above 70%)	Failed (Grade below 70%)
Lowest section.....	57	66%	53%	47%
Second section.....	72	69%	62%	38%
Third section.....	87	71%	72%	28%
Highest section.....	109	78%	82%	18%

Instead of the failures being almost entirely in the lowest quarter, as one would expect, considering intelligence alone, we find them distributed throughout the four sections, regularly decreasing in numbers with the increase of the intelligence score. Evidently there are other factors playing a large part in the

chemistry grades which operate equally among the students regardless of the degree of intelligence as indicated by this test. Any error in the chemistry or intelligence grading must be constant. It would seem desirable to have more than one intelligence test from which to take an average for each student as is the case with the chemistry grades considered in this paper.

Those who dropped out of chemistry, for all causes, before the end of the semester, had an average intelligence score of 67.7. This low score shows that these students would largely have been included in the lowest section had they remained to the end of the semester. Among these students there were evidently many, who through lack of study, became discouraged in their work and withdrew from the course. This left a higher percentage of industrious students in the lowest section, which might explain to some extent, the creditable showing of this group.

The grades on the different types of questions in the final examinations in chemistry showed the lowest average upon questions requiring some knowledge of mathematics or especially questions requiring accuracy and reasoning ability. Questions requiring memory work show the highest average. Jacob Cornog of the University of Iowa, in making a study of the examination questions in eighteen of the leading universities of this country found that 20% of them are chemical arithmetic and 18% have to do with equations, formulas and valence. In grading such types of questions the rule seems to be to give little or no credit unless the answer is correct throughout. Since such a large percentage of the work in chemistry depends upon accuracy, especially in simple mathematical problems, it was believed that this was the cause of many of the failures in chemistry.

In order to test the students in general chemistry on this point, two simple problems were given them.

Problem 1. If a dozen oranges cost 45 cents, what is the exact price of one orange (a), in dollars, (b) in cents ?

Problem 2. Solve the following proportion, carrying the answer out to six decimal places:

$$79.92 : 1.008 :: 35.46 : x$$

In case students did not know how to proceed to solve a proportion, they were told, in order that the solution would depend altogether upon their ability to multiply and divide. Both problems were solved correctly by 20.2% of the men and by 12.6% of the women, or by 17.8% of both men and women.

The effect of this upon our general chemistry is too evident to need comment.

It is almost impossible to get a satisfactory estimate of the time students spend in preparation for a course. In an attempt to solve this point, a group of 112 students was asked, at the end of a representative week, how much time each had spent during the week in the preparation of chemistry. The average time for the group was four hours and five minutes. There appears to be no reason to consider this an underestimate of the time they spent, and yet it is fifty-five minutes short of the required time as given by the college catalogue. It seems reasonable to believe that an increase of about one-fourth in the time devoted to the preparation of chemistry, or giving full time for preparation, would very materially decrease the percentage of failures in the course.

The grades of 96 freshmen taking both chemistry and mathematics were made the basis for a comparison of the grading systems of the two departments. No attempt was made to study the grades in other departments. The average grade of the students in chemistry and mathematics differed by 0.7%. The lower average was made in chemistry resulting in 3% more failures. It should be said however that the average chemistry grade of this group of students is 2% lower than that of the entire class. This is a very close agreement, when we consider that the only attempt to standardize the systems of grading in the two departments, is the rule that 70% is the passing grade.

Some points have been brought out, in this paper, which have an important bearing upon our grading system in general chemistry.

First: The comparison of the general chemistry grades with the intelligence score shows at least one thing, the chemistry grades are consistent.

Second: The preparation of the students in mathematics is certainly not up to the standard that we have a right to expect of college freshmen.

Third: The amount of time devoted to the preparation of the subject is about one-fourth short of the required time.

Fourth: The departments of chemistry and mathematics use about the same scale of grading.

These facts seem to justify the present standard of grading in general chemistry.

BULLETIN

OF THE

*West Virginia University
Scientific Association*

**VOL. I.
NO. 4**



**April
1924**

CONTENTS

	Page
List of Officers of the West Virginia University Scientific Association	8
Editorial Note.....	4
Programs of the Association.....	4
Names and Bibliographies.....	6
Departments of Law and of Arts and Sciences.....	16
Representation at Meetings of the National Societies.....	18
Departmental and Other Notes.....	20
Program of the State Geological Survey for 1924.....	21
The University and the Good Roads Program.....	22
The University Co-operates in Bridge Construction.....	23
Division of Tests, West Virginia State Road Commission.....	24
Mining Extension.....	25
The West Virginia Agricultural Experiment Station.....	27
The University and West Virginia Communities: Can We Co-operate, and How?.....	31
Report on Study of Morgantown Water Supplies.....	35
A Statistical Study of Five Hundred Autopsies.....	46

OFFICERS
OF THE
WEST VIRGINIA UNIVERSITY
SCIENTIFIC ASSOCIATION

PAST PRESIDENTS

A. R. Whitehill.....	1914-15
S. B. Brown.....	1915-16
F. E. Emory.....	1916-17
C. W. Waggoner.....	1917-18
B. H. Hite.....	1918-19
A. M. Reese.....	1919-20
Aaron Arkin.....	1920-21
N. J. Giddings.....	1921-22
R. P. Davis.....	1922-23

OFFICERS FOR 1923-24

President.....	G. S. Dodds
Vice-President.....	Geo. R. Bancroft
Secretary.....	J. H. Gill
Treasurer.....	E. R. Scheffel
Program Committee	J. H. Gill
	John L. Tilton
	R. L. Garber

EDITORIAL NOTE

The committee in charge of editing and publishing the Bulletin of the West Virginia University Scientific Association for the year 1923-1924 consists of the following: John L. Tilton, Chairman, N. J. Giddings, F. E. Chidester, W. W. Hodge, J. E. Winter, G. R. Bancroft.

A change is here made in the plan of numbering to favor those who may wish to bind the volumes. The present number becomes Vol. 1, No. 4, completing the volume. The numbers are now:

Vol. I, No. 1, May, 1922, which may be bound as Vol. I, No. 1.

Vol. II, No. 1, April, 1923, which may be bound as Vol. I, No. 2.

Vol. III, No. 1, December, 1923, which may be bound as Vol. I, No. 3.

Vol. I, No. 4, the present number, which may be bound as Vol. I, No. 4.

PROGRAM OF THE WEST VIRGINIA UNIVERSITY SCIENTIFIC ASSOCIATION

Report by the Secretary, J. H. Gill

The programs of the Association, including that of the meeting of the twenty-third of April, 1923, were published in the Science Bulletin of April, 1923. Since then the following programs have been given before the Association.

April 27, 1923. Dr. J. M. Dorsey, Professor of Horticulture, West Virginia University; subject, "The Hardness of Fruits." The subject was developed in a most interesting way, and the paper was discussed at considerable length. Climatic influences and changes of habitat were shown to produce great changes in the hardness of the various varieties of fruits.

May 10, 1923. The meeting was a joint meeting of the Scientific Association and the Sigma Xi Club. The speaker was Dr. E. L. Nichols, Professor Emeritus of Physics, Cornell University, subject, "Incandescent Oxides." The lecture was illustrated by many graphs showing the experimental data collected and the deductions made therefrom.

June 1, 1923. This was a business meeting to hear the reports of officers and committees and to elect officers for the ensuing year. The election resulted as follows: President, G. S. Dodds; Vice President, George R. Bancroft; Secretary, J. H. Gill; Treasurer, E. R. Scheffel; Committee on Programs, J. H. Gill, R. H. Garber, John L. Tilton.

October 26, 1923. The meeting was addressed by Dr. George R. Lyman, Dean of the College of Agriculture, West Virginia University, on the subject, "Cooperation in Scientific Research."

This was followed by a social time to meet the new science people who had joined the university force.

The December meeting was postponed on account of the Christmas recess.

January 25, 1924. This was a joint meeting with the Business Club of the University, addressed by Stephen Q. Hays of the Westinghouse Company, on the subject, "Hidden Resources of West Virginia."

February 8, 1924. The meeting was addressed by Dean C. R. Jones, Dean of the Engineering College, West Virginia University, on the subject, "Research Work at the Land Grant Colleges, the Work of the Engineering Experiment Stations and the Need of Federal Aid to Encourage This Work."

February 29, 1924. The meeting was a joint meeting with The Engineers Club of Morgantown, addressed by Calvin W. Rice, secretary of the American Society of Mechanical Engineers; subject, "A Travelogue on South America." The address presented a description of the social, industrial and engineering features in our sister continent.

March 27, 1924. Meeting of the University Scientific Society. The Speaker: Mr. T. D. Yensen, Research Engineer of the Westinghouse Electric and Manufacturing Co., Pittsburg, Pa. Subject: Recent Developments in Magnetic Materials. Illustrated.

April 25, 1924. Meeting of the University Scientific Society. The Speaker: Dr. I. C. White, State Geologist of West Virginia. Subject: The Geology of Petroleum and Natural Gas.

NAMES AND BIBLIOGRAPHIES

Papers published since Vol. II, No. 1, April, 1923.

ALLEN, HOWARD B. Assistant Professor of Agricultural Education.
B. S., Cornell, 1914; M. S., Cornell, 1920.

Author—West Virginia Vo-Ag. Teacher's Handbook Part II.
Miscellaneous contributions to West Virginia Agriculturist,
School Journal & Educator, Vo-Ag. News.

*AMIDON, LEE L. Instructor in Steam and Experimental Engineering.

B. S., M. E. Univ. of Minnesota, 1923.

Member Tau Beta Pi, Pi Tau Sigma, Iron Wedge (Senior
honorary society, Univ. of Minnesota).

*ARMENTROUT, WALTER W. Instructor in Farm Economics.

B. S., Agr. Univ. Tenn., 1916.

BANCROFT, GEORGE RUSSELL. Associate Professor of Physiological Chemistry.

*BIBBEE, P. C. Assistant in Zoology. (State Taxidermist).

B. S., Agr. W. V. U., 1921.

BOOMSLITER, GEORGE P.

Acceleration Stresses in Mine Hoists—in preparation.

BRECK, MARION FLORILLA. Assistant Professor of Education and
Home Economics.

M. S., Wisconsin, 1920.

*BUCHANAN, MARGARET. Assistant Professor of Mathematics.

Ph.D., Bryn Mawr, 1922.

CALLEN, ALFRED C.

Editor (in chief) Coal Mine Management (monthly). Published by
Burton Publishing Co., 1202 Monadnock Bldg., Chicago, Ill.

Author—Explosives—Bulletin—(6x9) pp. 77 (1923).

*CARPENTER, LEWIS VAN. Instructor in Structural and Hydraulic
Engineering.

B. S. C. E., W. V. U., 1918.

*New members of faculty since April, 1923 are marked by star. Positions
are named only in the case of first appearance in the Bibliography, or of change.

- *CATHER, CARL H.** Instructor in Mechanics.
B. S. M. E., W. V. U., 1916; M. S., Univ. of Illinois, 1922.
Member of the Engineering Faculty, West Virginia University 1916-21 and 1922 to date.
Member, Tau Beta Pi.
M. S. thesis at Illinois; Heat Transmission Losses Through Boiler Tubes Due to Soot and Scale.
- CATHER, HAROLD M.** Instructor in Mechanical Drawing.
B. S. M. E., Texas A. & M. College, 1917; M. S. M. E., W. V. U., 1923.
M. S. thesis at W. V. U.; Sampling Tubes for Steam Calorimeters—Reference Calorimeter.
- CHIDESTER, FLOYD EARLE.** Professor of Zoology.
Recent Developments in our Knowledge of the Internal Secretions. *Medical Times*. 51. 193-196.
Light as a Factor in Fish Dispersal. *Proc. Soc. Exp. Biol. and Med.* 20: 393-395.
A Historical Note on Sex Determination in Pigeons. *Science*. N. S. 58: 422.
The Origin of Cyclopean Monsters. *Am. Nat.* 57: 496-518.
- CLARK, FRIEND E.**
Chemical Education and Resources of West Virginia. *Chemical Age*, 30: 527. (1922).
A Study of the Action of Chloromethylbenzyl Ether on Salts of Organic Acids. *Bul. W. V. U. Scientific Society*, 3: 24-27. (1924).
The New Chemistry Building. *Bul. W. V. U. Scientific Society*, 3: 3-6. (1924).
- COLWELL, RACHEL HARTSHORN.** Professor of Home Economics.
B. S.; M. A. Columbia, 1905.
- CURRENCE, TROY MANSELL.** Assistant in Horticulture.
B. S., Agr. W. V. U., 1923.
- DAVIES, EARL C. H.**
Liesegang Rings III. The effect of Light and Hydrogen-Ion Concentration on the Formation of Colloidal Gold in Silicic Acid.
Gel. Rhythmic Bands of Purple of Cassius. *Jour. Amer. Chem. Soc.* 45: 2261-2268. (1923).
Electricity and Chemical Students. *Science N. S.* 59: 190. (1924).
- DAVIS, R. P.**
Specification for Highway Bridge. Published by West Virginia State Road Commission November, 1923.

Now working on revision of treatise on Foundations of Bridges and Buildings, by H. S. Jacoby and R. P. Davis. McGraw-Hill Book Company 1914. Revision all by R. P. Davis.

DODD, D. R. Agronomy Specialist, Agr. Ext. Staff.
B. S., Agr. W. V. U., 1914.

DODDS, G. S.
A new species of Phyllopod. Occasional Papers for Museum of Zoology, University of Michigan, No. 141, 1923.

DORSEY, M. J.
Sterility in Relation to Horticulture. Am. Jour Bot: 10: 474-484. (1923).
Factors Influencing the Set of Fruit, Proc. Ohio Hort. Soc. 1923: 24-30. Orchard Problems of Today. Proc. Ohio Hort. Soc. 1923: 31-38.
Dorsey, M. J. and Strausbaugh, P. D. Plum Investigations. Winter Injury to the Plum During Dormancy. Bot. Gaz. 76: 113-143 (1923).

EIESLAND, JOHN A.
On the Group of Motions in an Einstein Space. (In press).
On a Generalization of Kummer's surface in odd n -space. (In press).

*ENGLAND, WELCH. Assistant in Pathology and Bacteriology.
B. S. W. V. U., 1923.

FORMAN, ALEXANDER H.
Repairing and rebuilding certain parts of the University clock and the installation of new control equipment for announcing the time in the University Buildings.

*FRAME, N. T. Director Agr'l Extension.
A. B., Colgate, 1899.
Am. Country Life Assoc., Field Sec.; Nat'l Community Center Assoc.; Tuberculosis Assoc., W. Va. Exec. Com.; Com. on Town and Country Dep., International Y. M. C. A.; Nat'l Soc. Vocational Education; Nat'l Ed. Assoc.; Assoc. Land Grant Colleges; Nat'l Univ. Ext. Assoc.; Council of Social Agencies, W. Va. Exec. Com.; W. Va. Beautification Conference, President.
Principal High School—Black River; Asst. Supt. George Junior Republic, Freeville, N. Y.; Hotel Manager, Daytona, Fla.; Manager Clarion Concrete Construction Company, Baltimore, Md.; Instructor School of Life Ins. Salesmanship, 209 Broadway, N. Y.; Sales Manager, A. H. D. Co., Martinsburg, W. Va.; Farmer and Orchardist, Berkeley County, W. Va.; County Agent, Louisville, Ky.; State Agent, Morgantown, W. Va.

The Battle of Sandy Creek in the War of 1812—A monograph published in 1894 by the Jefferson County (N. Y.) Historical Society.

The Adventures of Sir Hubert—published in Farm and Fireside.

Focusing on the Country Community, Extension Cir. 211.

Lifting the Country Community by its Own Bootstraps, Extension Cir. 255.

Helping the Country Community Saw Wood, Extension Cir. 265.

GARBER, R. J. Professor of Agronomy.

Ph.D., Univ. Minn., 1922. Fellow A. A. A. S.

Member of Am. Genetic Association.

Garber, R. J. and Quisenberry, K. S. Delayed germination and the Origin of False Wild Oats. Jour. of Hered. 14: 267-274. 1923.

***GIBSON, J. KNOX.** Instructor in Anatomy.

B. S., W. V. U., 1923.

GIFFORD, WARREN. Assistant, Dairy Husbandry.

B. S. Agr., W. V. U., 1923.

GILL, JAMES H.

Mixing of Metals to Secure Special Results.

Heat Treatment of Steels.

Tests of Various Kinds of Cutting Tools.

The Design of a Machine to Test Revolving Parts for Static and Dynamic Balance.

GRAY, T. D. Specialist in Horticulture, Agr. Ext. Staff.

B. S. Univ. Md., 1915.

GRUMBEIN, JOHN B.

Investigation in Progress: Sampling Tubes for Steam Calorimeters—Reference Calorimeters.

Designing: New Steam Heating Tunnel to care for the new Chemistry Building, and other new buildings planned, also extensions to the Central Heating Plant.

A. S. M. E. Report to the Power Test Code Committee, A. S. M. E. to be published.

HAMMOND, ELMER LIONEL. Instructor in Pharmacy.

B. S., Mich., 1921; M. S., Mich., 1923.

***HARKINS, DUNCAN CLAIRE.** Instructor in Mathematics.

A. B., W. V. U., 1921; A. M., W. V. U., 1923.

***HARSHBARGER, FRANCES.** Graduate Assistant in Mathematics.

A. B., Grinnell College, 1923.

HARTLEY, CHAS. HENRY. Asst. Director Agri. Ext. Div..
B. S., W. Va. Wesleyan, 1908; B. S. Agr., W. Va. Univ., 1918.
In charge Science Dept. Beaver H. S., Bluefield, W. Va.,
1908-11; Prin. same H. S. 1911-12; Asst. to Director Agri.
Ext. 1914-19; in charge of State H. S. Literary Contest,
1923.

HENDERSON, HARRY OLAM. Assistant Professor Dairy Husbandry.
B. S., Pa. State College, 1915; M. S., Pa. State College,
1916.
Member of the National Dairy Science Association.
County Agricultural Agent, Pennsylvania, 1916-1919; Dairy
Extension Specialist, West Virginia Univ. 1919-1920.
A Study of Forced Feeding and Methods Used in Advanced
Registry Feeding, Pa. Exp. Sta. Rep. 1916.
Sunflowers vs. Corn for Silage, (Joint author) Circular 32,
W. Va. Agr. Exp. Sta., 1920.
Feeding Dairy Cows, (Joint author) Circular 251, W. Va.,
Ext., 1920.
Soybean vs. Alfalfa Hay for Milk Production, (Joint author)
Bulletin 181, W. Va. Agr. Exp. Sta., 1923.

HILL, HARRY. Assistant in Physics.
A. B., W. V. U., 1922.
Member, Am. Physical Society.

HILL, HUBERT.
Glass. W. V. U. Scientific Society Bulletin 3: 10-17. 1923.

HODGE, WILLARD W.
Investigation in progress on Quality of Some Water Supplies;
Rate of Corrosion of Certain Alloys.
Abstractor—Chemical Abstracts—Published by American
Chem. Soc.
Member: Society Chemical Industry, London, Eng.

***HOPKINS, James Vincent.** Dairy Specialist, Extension Division.
B. S. Agr., Univ. Tenn., 1917.
Professor Agriculture, Marysville College, Marysville, Tennessee, 1918-1922; Manager, Bellwood Dairy and Stock Farm, Marysville, Tennessee, 1916-1923; Instructor Agriculture and Biology, Polytechnic School, Marysville, Tennessee, 1919-1921.
Mem. American Dairy Science. Assoc.

***HUTCHESON, EDITH MARIAN.** Assistant in Chemistry.
B. S. Education, Ohio State, 1923.

JACOBSON, CARL ALFRED.
Hydrofluosilicic Acid. Bul. de l'Academie Polonaise' des
Science et des Lettres. Feb. 1922.

- Fluosilicic Acid. The maximum Concentration of the Acid at Room Temperature. *Journal of Physical Chemistry*. 27: 577. (1923).
Fluosilicic Acid II. (The State of the Acid). *Jour. Phys. Chem.* 27: 761. (1923).
A Reagent Bottle Siphon. *W. V. U. Scientific Society Bulletin* 8: 28-30. 1923.
A Novel Calculating Machine. *W. V. U. Scientific Society Bulletin* 3: 30-34. 1923.
Chemical Spelling Contest of 1921. *W. V. U. Scientific Society Bulletin* 8: 34-39. 1923.

*JOLLIFFE, N. H. Assistant in Physiological Chem. and Physiology. B. S., W. V. U., 1923. A. A. A. S.

JONES, CLEMENT R

- Tau Beta Pi—1922.
The College of Engineering, Published in West Virginia Alumni Magazine. 23A: 50. (1923).
Editor—Engineering Experiment Station Record (Quarterly).
Editor—Engineering Experiment Station Summary and Index.
Secretary—Engineering Section—Land Grant College Association.
Member of Engineering Experiment Station Committee—Land Grant College Association.
Address—Engineering Research in Land Grant Colleges—before West Virginia University Scientific Society. 1924.

*KOEHLER, WILLIAM A. Instructor in Chemical Engineering. B. S., Univ. of Wisconsin, 1919; Ch.E., Wisconsin, 1920; M. S., Univ. of Illinois, 1922.
Member, American Ceramic Society, Tau Beta Pi, Phi Pambda Upsilon, Sigma XI.
Member of the Chemical Engineering Staff, University of Wisconsin, 1919-1920. Research Chemist with the Carborundum Company, 1920-21.
Physical Characteristics of Specialized Refractories, (with Mr. M. L. Hartmann of the Carbonundum Co.). *Journ. Amer. Electro.-Ch.-em. Soc.* 40: 457. (1921).

LAWALL, CHARLES E.

- Dry Preparation of Bituminous Coal. *Coal Mine Management*, 2: 11. (1923).
Faults of Erosion vs. Displacement. *Coal Age*. 24: 21. (1923).
Training Future Coal Mining Executives, Paper presented before the West Virginia Institute at Huntington, W. Va., Dec. 1923.

***LLOYD, TOM COX.** Instructor in Electrical Engineering.
B. S. E. E., Carnegie Institute of Technology, 1923.
Member, Eta Kappa Nu.

***LYMAN, G. R.** Dean, College of Agriculture.
B. A., Beloit 1894; A. B., Harvard, 1897; A. M., Harvard, 1899; Ph.D., Harvard, 1906; Phi Beta Kappa, A. A. A. S., Bot. Soc of Am., Am. Phytopath. Soc., Wash. Acad. Sci., Am. Soc. Naturalists, Am. Acad. Arts and Sciences. Instructor in Botany, Radcliffe, 1900-01; Instructor in Botany, Dartmouth 1901-04; Assistant Professor Botany, Dartmouth 1904-14; Pathological Inspector, Federal Horticultural Board, 1915-17; Pathologist in charge of Plant Disease Survey, 1917-23.

Culture studies on the Polymorphism of *Hymenomycetes*.
Proc. Bost. Soc. Nat. Hist. 33: 125-209. Pl. 18-26.

Keys to the Trees of Hanover, N. H. Based on Winter Characters and on Leaves.. Issued by Dartmouth College, 1909.

The Trees and Shrubs of Hanover, N. H. Issued by Dartmouth College, 1911.

Keys to Fungi of Hanover, N. H. Privately issued, 1912.

Outlines of Cryptogamic Botany (a projected text book).
Privately issued, 1914.

The Native Habitat of *Spongospora Subterranea*. Science N. S. 42: 940-941. (1915).

The Need for Organization of American Botanists for More Effective Prosecution of War Work. Science N. S. 47: 279-284. (1918).

The Relation of Phytopathologists to Plant Disease Survey Work. Phytopathology 8: 219-228. (1918).

The Unification of American Botany. Science N. S. 49: 339-345. (1919).

The Advisory Board of American Plant Pathologists. Phytopathology 9: 202-206. (1919).

Potato Wart: U. S. Dept. of Agr.. Circular. 1920.

Miscellaneous reports and summaries on distribution, severity, etc., of plant diseases in the U. S.

Plant Disease Bulletin 1917 to 1923.

MACLIN, EDWARD S. Professor of Industrial Education.
B. S., in Education (University of Tennessee, 1916).
Joint Author of Descriptive Geometry with A. V. Millar and L. J. Markwardt.
Member National Society for Vocational Education, National Education Association, Society for the Promotion of Engineering Education, American Management Ass'n.
High school teacher 1908-1910. Instructor in drawing and descriptive geometry in University of Wisconsin 1910-1914,

High school teacher 1914-1918, University of Tennessee and State Department of Education in Vocational Education, 1918-1920., War Plans Division, U. S. A., 1920-1921.

MILNER, MARY ALICE. Instructor in Home Economics.
B. S. H. E., Ohio State, 1917.

MORRIS, S. J. Professor of Anatomy.
Research at Harvard Medical School, 1922-23.

***MORROW, J. F.** Assoc. Prof. Pharmacology and Physiology.
B. S., W. V. U., 1920.; M. D., Univ. Cincinnati, 1923.
Assistant in Anatomy, W. V. U. 1920-21.
Aneurysm of the Vertebral Arteries. *Med. Rec.* Nov. 19, 1921.

***OLNEY, ROY ADAMS.** Assistant Professor of Agricultural Education.
B. S., Cornell, 1915.
Assoc. Editor *Vo-Ag. News*. West Virginia *Vo-Ag. Teacher's Handbook* Part III.

***PARSONS, DICKSON WARD.** Instructor in Agricultural Education.
B. S., W. V. U., 1905; M. S. Wisconsin, 1918.

QUISENBERRY, KARL S.
Alpha Zeta.
A Multiflorous Variation in Burt Oats. (Coffman & Quisenberry). *Jour. Hered.* 14: July, 1923.
Delayed Germination and the Origin of False Wild Oats. (Garber & Quisenberry). *Jour. Hered.*, 14: September, 1923.

REESE, ALBERT M.
The Habitat of the Crocodilia of British Guiana. *Ecology*, 14: 141-146. (1923).
The Osteology of Tegu, *Tupinambis nigropunctatus*. *Jour. Morph.* 38: 1-16. (1923).

SCHEFFEL, E. R. Member Ohio Academy of Science; Mem. National Council of Geography Teachers.
Soot in Coal. *Science* N. S. 59: 212-213. (1924).
A note on vertebrate remains in the middle Conemaugh. In course of preparation.

SIMPSON, JOHN N.
Variation of the Conception of Medical Education. Pres. Address, W. V. State Medical Association, June, 1923. 56th Annual Meeting. Published *W. V. Medical Journal*, July, 1923.

***SMITH, WILLIAM ADAMS.** Professor of Pathology and Bacteriology.

M. D. 1905. C. M. 1905 (Queens University, Canada).
 Interne, St. Mary's Hospital, Rochester, N. Y. 1905-1907;
 Pathologist N. Y. State Hospitals, 1907-1912; House Surgeon, Laura Franklin Free Hospital for Children, 1914;
 Captain, Canadian Army Medical Corps, 1915-1919; Pathologist, Norwich (Conn.) State Hospital 1920-23.

SPRAY, ROBB SPALDING, Ph.D., Univ. Chicago, 1923.

A *Diplococcus* Associated with Caseous Lymphadenitis and Pneumonia of Sheep. *Jour. Infect. Dis.* 33: 161-168. (1923).

Bacteriologic Study of Pneumonia in Sheep. *Jour. Infect. Dis.* 33: 97-112. (1923).

***STILLWELL, ERWIN CHARLES.** Instructor in Animal Husbandry. M. S., Iowa State College, 1923.

***STRAUSBAUGH, PERRY DANIEL.** Professor of Botany and Head of Botany Department.

B. S., College of Wooster, 1923; Ph.D., Univ. Chicago, 1920.

A. A. A. S.; Bot. Soc. Am.; Ecological Soc. Am.; Ohio Academy Science; Sigma Xi; Gamma Alpha.

Instructor in Biology, College of Wooster 1913-15; Asst. Prof. of Botany, College of Wooster, 1915-20; Prof. of Botany, College of Wooster, 1920-23. Research Fellow in Department of Botany, Univ. Chicago, 1918-1920.

Fuller, Geo. D. and Strausbaugh, P. D. On the Forests of La Salle County, Illinois. *Trans. Ill. Acad. Sci.* 12: 246-272. (1919).

Strausbaugh, P. D. Dormancy and Hardiness in the Plum. *Bot. Gaz.* 71: 337-357.

Dorsey, M. J. and Strausbaugh, P. D. Winter Injury to Plum During Dormancy. *Bot. Gaz.* 76: 113-143.

***SWAN, WILLIAM ORR.** Instructor in Chemistry.

B. S., Univ. Miss., 1919; M. S., Univ. Va., 1921; Ph.D., Univ. Va., 1922. Phi. Beta Kappa; Alpha Chi Sigma. Research Fellow, Univ. Va., 1919-22. Acting Assistant Professor in Chemistry, Univ. Va. 1922-23.

***THOMPSON, MARION ROSE.** Instructor in Home Economics. B. S. H. E. Wisconsin, 1923.

TILTON, JOHN L. Professor of Geology and State Palaeontologist. Observation on Coal Swamps in Northern West Virginia, where Permian Conditions Prevail. *Abstract, Bul. Geol. Soc. Am.* 34: 72. (1923).

The Missouri Series of the Pennsylvania System in Southwestern Iowa. The Iowa Geological Survey, 28.

A Convocation Address and a High School Address, both on Geology.

The Geology of Hampshire County, West Virginia. In course of Preparation.

***TRAIL, RUTH KATHRYN.** Assistant Professor of Home Economics. B. S., Connecticut College, 1919; M. S., Kansas State Agricultural College, 1922.

Instructor in Food Econ. and Nutrition Dept., K. S. A. C., 1919-1923.

Member: Phi Kappa Phi; Am. Home Econ. Ass'n.

Bogert, L. J. and Trail, R. K. Studies in Inorganic Metabolism III; Studies in Inorganic Metabolism IV; The Influence of Yeast and Butter Fat upon Calcium Assimilation, Jour. Biol. Chem., 1922, liv. 387; The Influence of Yeast and Butter Fat upon Magnesium and Phosphorous Assimilation. Jour. Biol. Chem., 1922, liv., 753.

***TROUT, G. M.** Instructor in Dairying.

B. S., Iowa State College, 1923.

***TURNER, BIRD MARGARET.** Assistant Professor of Mathematics. A. B., W. V. U., 1915; A. M., W. V. U., 1917; Ph.D., Bryn Mawr College, 1920; American Mathematical Society; Mathematical Association of America; Phi Peta Kappa.

Principal of High School, Moundsville, W. Va., 1915-16; Assistant Director Phoebe Anna Thorne Model School, Bryn Mawr College, 1917-18; Reader in Mathematics, Bryn Mawr College, 1918-19; Instructor in Mathematics, University of Illinois, 1920-23.

Plane Cubics with a Given Quadrangle of Inflexions, Amer. Jour. of Mathematics. 44: Oct. 1922.

On the Positions of the Imaginary Points of Inflexion and Critic Centers of a Real Cubic. Annals of Mathematics 23: June, 1922.

***TURNER, ROBERT GRAHAM.** Instructor in Chemistry.

B. A., Lawrence College, 1920; M. S., State University of Iowa, 1922.

American Chemical Society; Instructor in Chemistry, State University Iowa, 1921-1922; Instructor in Physiological Chemistry, Emory University, Ga., 1922-23.

VANDERVORT, HU SWISHER. Assistant Director in Charge of Horticulture.

Agronomy, and Dairying. Agr. Ext. Staff. .

B. S., Agr. W. V. U., 1911.

VAN DEVER, GEORGE JAY. Assistant Poultry Specialist. Agr. Ext. Staff.

B. S., Rutgers, 1921.

*WADE, BRYAN LLEWELYN. Assistant in Agronomy. B. S., Agr. W. V. U., 1923.

WINTER, JOHN E. Professor of Psychology.

DEPARTMENTS OF LAW AND OF ARTS AND SCIENCES

PRESIDENT TROTTER'S duties take him to all educational meetings of the state within reach, where he is a frequent speaker upon educational topics.

AMBLER, CHARLES H. Professor of History.

Influences of the Ohio River in American History. (In preparation.)

ARNETT, L. D. now has ready for publication a book on "Library Methods."

CALLAHAN, JAMES M. Professor of History and Political Science. New volume on West Virginia History.

Various articles for the latest edition of the American Encyclopedia, covering topics in diplomatic relations, history of the West, conservation, European colonization, League of Nations, World Court, Mexican troubles, Chile and Peru Problems, Central American relations, and arbitration and peace.

Syllabus on case problems in international law. (In preparation).

CARLIN, LEO. Professor of Law.

Methods of Objecting to Process and Amendment Thereof in West Virginia, 29 W. Va. Law Quar. 229-246.

Answer in Equity as Evidence in West Virginia, 29 W. Va. Law Quar. 45-53.

The Necessity for Pleading a Traverse, 29 W. Va. Law Quar. 128-134.

CHITWOOD, OLIVER P. Professor of History.

Two chapters in the latest edition of the history of West Virginia.

Article on the Historical Activities of West Virginia During the World War. Published in the 1923 report of the American Historical Association.

Two Sketches for the Manual of Historical Literature. To be published under the auspices of the American Historical Association.

Book reviews as follows:

History of Lewis County, by E. C. Smith.

The Myth of a Guilty Nation, by A. J. Nock.

History of the English Colonies in America. (In preparation).

- CUNNINGHAM, H. E.** Professor of Philosophy.
Text book on Logic. (In preparation). To be published by Macmillan.
- DICKINSON, E. C.** Professor of Law.
Parent's Liability for Child's Negligence in Operating Family Automobile, 29 W. Va. Law Quar. 53-57.
- HARDMAN, T. P.** Professor of Law.
Social Interest in the Aesthetic and the Socialization of the Law, 29 W. Va. Law Quar. 195-198.
Book reviews as follows:
The Nature of the Judicial Process, by Benjamin N. Cardozo, 29 W. Va. Law Quar. 145-148.
A Selection of Cases Under the Interstate Commerce Act, by Felix N. Frankfurter, 29 W. Va. Law Quar. 290-291.
An Introduction to the Philosophy of Law by Roscoe Pound, 29 W. Va. Law Quar. 285-288.
- HARRIS, T. L.** Professor of Sociology.
Science Plus Common Sense in Rural West Virginia. An article to appear in the Journal of Social Forces, published by the University of North Carolina.
- MADDEN, JOSEPH W.** Professor of Law.
The American Law Institute, 29 W. Va. Law Quar. 149-157.
Purchaser for Value, 29 W. Va. Law Quar. 121-127.
Book Review:
The Law of Building and Loan Associations, by Joseph E. Sundheim, 29 W. Va. Law Quar. 78-74.
- SHORTRIDGE, WILSON P.** Professor of History.
The Transition of a Typical Frontier, published by George Banta and Co., Menasa, Wis.
Kentucky Neutrality in 1861, published in the Mississippi Valley Historical Review.
- SPIKER, CLAUDE C.** Associate Professor of Romance Languages.
The Historical Development of the Cesura in the French Decasyllable. A dissertation ready for publication.
- STATHERS, MADISON** Professor of Romance Languages.
A class edition of Histoire d'un Conscrit de 1818 by Erckmann-Chatrian, published by Ginn and Co.
- STONE, H. E.** Dean of Men.
Various articles on the general topic of the choice of one's life work, published in the West Virginia School Journal, Journal of Education, Christian Science Monitor, Christian Education and Educational Review.

REPRESENTATION AT MEETINGS OF THE NATIONAL SOCIETIES

The University has been represented by attendance as follows at the various national societies.

The A. A. A. S. and the various affiliated and other societies that met at Cincinnati during the holidays: S. B. Brown, F. E. Chidester, M. J. Dorsey, E. F. George, N. J. Giddings, W. J. Kay, H. E. Knowlton, L. H. Leonian, G. R. Lyman, F. A. Molby, C. L. Reynolds, E. R. Scheffel, E. C. Sherwood, P. D. Strausbaugh, L. H. Taylor, J. E. Winter, E. E. Zimmerman.

The Am Chem. Soc.: F. E. Clark, C. H. Davies, E. P. Deatrick, Mrs. L. B. S. Deatrick, W. W. Hodge, C. A. Jacobson, Samuel Morris.

Am. Railway Eng'g. Assoc., bi-monthly meeting—Com. on Iron and Steel Structure: R. P. Davis.

Am. Soc. Mechan. Eng'g.: L. D. Hayes, J. B. Grumbein.

Am. Soc. for Treat. Steel: J. H. Gill, W. O. Gnagey, L. D. Hayes, W. W. Hodge.

Geol. Soc. of Am.: John L. Tilton.

Coal Mining Inst. of Am.: A. C. Callen, A. Crawford, C. E. Lawall.

Am. Soc. Hort. Sci.: M. J. Dorsey, N. J. Giddings, G. R. Lyman, K. C. Westover.

Am. Psych. Assoc.: J. E. Winter.

Miss. Valley Hist. Assoc.: C. H. Ambler, J. M. Callahan, W. P. Shortridge.

Am. Soc. International Law: J. M. Callahan.

Am. Hist. Assoc.: C. H. Ambler, J. M. Callahan, O. P. Chitwood, H. S. Mitchell, W. P. Shortridge.

Am. Polit. Sci. Assoc.: J. M. Callahan.

Am. Assoc. Univ. Professors: A. R. Armstrong, H. E. Cunningham.

Am. Assoc. State Univ.: Pres. F. B. Trotter.

The Southern Assoc. of Colleges and Secondary Schools: Pres. F. B. Trotter.

Nat'l Ed. Assoc.: J. M. Callahan.

Nat'l Ed. Assoc., Div. of Pres. and Supt.: Pres. F. B. Trotter, H. C. Humphreys, F. H. Doeden.

Assoc. of Am. Medical Colleges: Pres. F. B. Trotter, Dean J. N. Simpson.

Cong. on Medical Ed. and Licensure: Pres. F. B. Trotter, Dean J. N. Simpson.

Land Grant Col. Assoc.: Pres. F. B. Trotter, Dean C. R. Jones, Dean G. R. Lyman, N. T. Frame, H. G. Knight.

Soc. for Promotion of Eng'g Edu.—Meeting of Deans and Executives, Ithaca, 1922, Ann Arbor, 1923: Dean C. R. Jones.

Southern Medical Assoc.: Dean J. N. Simpson.

Arnett, L. D. is President of the West Virginia State Library Association.

Kay, W. J. is President of Nat'l Assoc. of Teachers of Speech.

Lyman, Dean G. R., is President of the Am. Phytopathological Society.

Jacobson, C. A. was recently elected a member of Phi Beta Kappa at his Alma Mater, Carlton College, Minn.

Jones, Dean C. R., is Secretary of the Land Grant College Association.

DEPARTMENTAL AND OTHER NOTES

Extensive and valuable additions have recently been made to the equipment of the Power Room Laboratory of the Department of Steam and Experimental Engineering. Included among these are a Chain Grate Stoker, Bland W. Boiler, Unaflo Engine and Generator.

Professor Alfred C. Callen has been the President of the West Virginia Coal Mining Institute during the year, 1923.

The shop laboratories of the College of Engineering have been enlarged and considerable new equipment installed during the past year. The equipment of the Shop Laboratories is fairly representative of good modern practice. The machine shop is being equipped to illustrate modern production methods by the use of semi-automatic, full automatic and special machines. Professor J. H. Gill, who is in charge of the department is at work upon the design of a machine to test revolving parts for static and dynamic balance. It is hoped to make this machine useful in the line of machine construction to demonstrate the effect of unbalance in high speed machines to locate and correct for this unbalanced condition.

In the Department of Electrical Engineering, under the direction of Alexander H. Forman, a new shop for electrical construction work is now being arranged, and a new laboratory for the calibration of instruments is being equipped. Mr. A. A. Hall, formerly Associate Professor of Electrical Engineering, but last year (1922-1923) City Manager for the city of Morgantown, has returned to the staff as Professor of Electrical Engineering. Mr. T. C. Lloyd is a new instructor in the department.

In the Department of Chemical Engineering, under the direction of Willard W. Hodge, considerable new apparatus and equipment has been added to the laboratories during the past year for metallurgical and other chemical work. Mr. W. A. Koehler has joined the staff as Instructor in Chemical Engineering. His special training and experience along ceramic lines will enable the department to offer courses in glass and ceramic work as the demand comes for such courses.

B. B. Kaplan is the Chemist of the West Virginia Geological Survey. The first five months he was on leave of absence at Harvard where he was at work on a research problem bearing on the Nernst-Warmes Theory. Since his return he has taken up work again on this special problem and hopes to have a paper on the subject ready some time next summer. He has also analyzed the minerals from Mercer and Monroe counties which include samples of limestone, iron ores, manganese ore, clays, shales and coal, on which a bulletin is now in preparation for publication. He is also engaged in determining the fusing points of all West Virginia coals, and is analyzing the coal ashes to ascertain the relation between the chemical compositions of coal ash and its fusing point. He has recently perfected a gas and compressed air furnace that gives a temperature of 3000 degrees.

PROGRAM OF THE STATE GEOLOGICAL SURVEY FOR 1924

By Dr. I. C. White, State Geologist.

TOPOGRAPHIC WORK

The topographic mapping field work, covering the entire area of the State on a scale of 1:62,500 was completed July 1st, 1923. Since this date the topographic corps of the United States Geological Survey has been engaged in revising the older or first surveyed quadrangles, the Morgantown, Bruceton, Blacksville, Fairmont, Mannington, Clarksburg, Thornton and Kingwood, eight in all having been completed so far as field work is concerned in 1923, ready for the engraver. These revised quadrangles should be issued sometime during 1924. The work of revision will be continued during the field season of 1924, and probably fifteen to twenty other quadrangles will be brought up to date, by these Co-operative Revision Surveys during the present year.

GEOLOGIC WORK

Dr. Tilton and Mr. Price will finish the manuscript of the Detailed Report on Hampshire County, and then take the field, probably in Pocahontas County, while Dr. Prouty and Mr. Tucker after completing the manuscript of the Detailed Report on Hardy County, will probably take the field for the Survey of Pendleton County. Mr. Reger after completing the manuscript of Mercer, Monroe and Summers will take up the Survey of Randolph County.

PUBLICATIONS

During the year 1924, the Detailed Report on Grant and Mineral Counties by Mr. Reger which is now (February 8th) about two-thirds (2-3) printed, should be issued while the Economic and Structural map of Ohio, Brooke and Hancock Counties by Mr. Tucker should be issued before the close of the year.

THE UNIVERSITY AND THE GOOD ROADS PROGRAM

By R. P. Davis, Professor of Structural and
Hydraulic Engineering

The Engineering Department of the University has played an important part in the good roads program of West Virginia. The legislature of 1913 created a state road organization and made the chief road engineer a member of the engineering college faculty. The function of the first road bureau was to create sentiment among the people of the state for good roads and assist the county courts through expert engineering advice in the construction of roads. No funds were provided by the state to carry on the work of the road bureau and so this financial burden was borne by the engineering school until the 1915 session of the legislature. During these early years of the good roads work there was the closest co-operation between the college of engineering, particularly the civil engineering department, and the road bureau. Schools for good roads were held each winter, the instructors delivered lectures over the state promoting the sentiment for good roads, expert engineering advice was available for the asking, and materials were tested without charge.

Many of the staff of the state road commission received their training at the University. The chairman of the commission, Major C. P. Fortney, is a graduate in civil engineering of the class of 1907. Of the five division engineers, two are likewise graduates in civil engineering. These are W. S. Downs of the class of 1906 and H. E. Snyder of the class of 1909.

The offices of Division No. 4 are located in Mechanical Hall, occupying nearly all of the third floor of the middle of the building and one room on the second floor. This division comprises twelve counties adjoining the Maryland and Pennsylvania lines and extending well down into West Virginia. All road work for these counties is carried on at Morgantown, this work including the preparation of plans and designs. This affords very close contact between the students in the college of engineering and the division.

This division is manned for the most part by University graduates and during the summer employment is furnished many of the students. The close association between the college of engineering and the road commission is of mutual benefit, affording a wonderful stimulus to the students and furnishing a ready source of trained engineers to the commission.

THE UNIVERSITY COOPERATES IN BRIDGE CONSTRUCTION

By R. P. Davis, Professor of Structural
and Hydraulic Engineering

The Engineering Department of the University co-operates and assists in the design and construction of much of the bridge work that is done in West Virginia. When the original State Road Bureau was organized in 1918, Dr. R. P. Davis, head of the department of structural and hydraulic engineering in the College of Engineering, was made bridge engineer for the bureau.

The early work consisted of the preparation of standard plans and specifications for bridges of both steel and concrete and of assisting the counties and cities of West Virginia in getting good bridges at reasonable prices. At that time the public was suspicious of most bridge contracts by reason of exposures often made of graft and bribery. By furnishing free engineering service to the counties the state road bureau helped toward placing bridge construction on a more business-like basis, resulting in better bridges at lower prices.

Since 1919, when the office of the State Road Commission was moved from Morgantown to Charleston, the department of structural engineering has acted as consulting bridge engineer for the commission, the work being confined mostly to the preparation of standard specifications, the design of large bridges and the making of special estimates.

The staff of the bridge department of the State Road Commission is composed largely of the graduates of the University in the department of civil engineering. Among these are the bridge engineer and the two senior assistant engineers. At the present time this staff is designing annually work valued at over a million dollars.

Among the larger pieces of bridge work in which the engineering department of the University has co-operated with the State Road Commission are the bridge over the Cheat river in Monongalia county, the bridge over the West Fork river at Gypsy in Harrison county, the bridge over the Elk river at Hartland in Clay county and the bridge at Witcher in Kanawha county. Numerous bridge investigations have been made to determine the strength and carrying capacity of existing structures. Among these are the bridge over the Kanawha river in Charleston, the Third avenue bridge over the Guyan river in Huntington, the bridge over the Monongahela river in Morgantown and a number of bridges over the Potomac river. Estimates were recently completed on the cost of three proposed bridges over the Kanawha river in Kanawha county.

A considerable amount of research work along bridge lines is being carried on at the University, this work being done by the testing department of the State Road Commission using, for the most part, University equipment. To determine the best paints for steel bridges actual exposure tests of about seventy paints have been in progress for the last two years. Bond tests of steel bars to concrete have been made as well as tests to determine the strength of cast-iron bridge shoes.

DIVISION OF TESTS, WEST VIRGINIA STATE ROAD COMMISSION

By R. B. Dayton, Materials Engineer, State Roads Commission

The testing department of the State Road Commission is located in the Mechanical Hall of the State University. The personnel of this department at the present time consists of a materials engineer, assistant materials engineer, chemist, five laboratory men, one stenographer and four part time laboratory helpers.

In addition to the regular routine work of the laboratories, considerable time is spent in the field on project material surveys, inspection of commercial plants and inspection of materials being used in the construction of roads and bridges. Investigations along particular lines are carried on during the winter months.

The following tabulation is a summary of the routine tests conducted by the laboratories during the past year..

SAMPLES

Portland cement	1027
Sand and stone screenings	382
Asphalt sand	31
Rock	402
Concrete	744
Paint	116
Gravel	168
Sand and gravel.....	8
Asphalt	157
Tar	8
Concrete pipe	30
Slag	93
Steel	43
Brick	7
Asphaltic concrete	64
Lubricating Oil	30
Miscellaneous	31
Chemical analysis of rocks, cements, etc.....	130
 Total	 3456

MINING EXTENSION

By Adam Crawford, Assistant Director of Mining Extension

The Mining Extension movement in West Virginia which was begun in September, 1914, has grown very rapidly in respect to the number of classes that are being conducted and has become very popular. In many of the large coal producing counties it is looked upon both by the operator and miner as a permanent work through which the individual and the industry can derive great benefits.

The purpose of Mining Extension is to establish and conduct night classes in mining in the various coal mining centers throughout the State in order that mining men may have an opportunity to improve their knowledge in the various branches of the industry. In this way it is believed that those who attend these classes become more efficient as workmen or as officials, and they in turn help to make the industry safer and more productive.

This work was started in September, 1914, under the direction of E. N. Zern who was at that time Professor of Mining Engineering. One instructor was employed to conduct the classes that were established at Ramage and Decota in the Kanawha field, and Glen White, Raleigh, Tams, McAlpin and Athens in the New River field. The work during that year was practically an experiment. However, the results that were obtained warranted the addition of two more instructors, to the field force for the year beginning September 1915.

The work during the second year was confined to the southern end of the State. Headquarters for the three instructors were established at Montgomery, Athens and Welch, respectively. A total of 15 classes were organized and conducted in these three districts. The instructor would meet a class once in every two weeks and lecture or demonstrate by means of lantern slides, such subjects as mine ventilation, timbering, safety lamps, mine gases, etc. The total attendance for the three districts during the year was 1806.

The work continued to grow each year and at the beginning of the extension work for 1917 it was found necessary to add another instructor to the staff. This permitted more centers to be established from which more classes could be reached. A total of 2076 men attended the classes during that year.

On November 1, 1917 when Professor A. C. Callen became Director of the Mining Extension Department and Professor of Mining Engineering, succeeding Professor E. N. Zern, there was

only one man on the staff, the others having resigned. On January 15, 1918 an instructor was secured. His headquarters were established in Fairmont and classes were conducted in that district which were the first ones in the northern end of the State since the work was first instituted. Practically no changes were made in the way the classes were conducted. At the close of the year only one instructor remained on the staff, the other was forced to resign on account of ill health.

During the year 1918 the work was carried on in the Fairmont district and the Elkins district. Considerable difficulty was experienced at that time in securing instructors, therefore the work could not be expanded. However, the two districts had an enrollment of 524.

At the beginning of the year 1918 the work was reorganized on a new basis. Each instructor had five classes located at five different points. Each class was held one night every week. Special forms were prepared for the enrollment of each student whose record of attendance was kept by the instructor. The use of lantern slides was discontinued and blackboard instruction substituted in connection with lectures. At the close of each lesson, questions to be worked at home pertaining to the lesson of the evening were given to each student. The student returned his answers the following week to the instructor for correction. Four unit courses consisting of the study of mine gases, safety lamps, ventilation and timbering comprised the year's work and at the completion of the course a certificate of attendance was awarded to those that made an average attendance of 80 per cent.

The method that was adopted in 1918 is the one in use at the present time. Its success is evidenced by the fact that in 1922 and 1923 six instructors were employed and thirty classes were conducted. The total enrollment was 1516 with an average weekly attendance of 643.51. This year the staff consists of seven instructors who conduct a total of 35 classes that are located in some of the most important coal districts.

In reviewing the growth of this work, the co-operation that has been received from the coal companies and their employees, and the State Department of Mines has been a very important factor. In many instances manager and miner attend the same class and discuss the questions that are presented. On the other hand young men are encouraged to attend these classes to fit themselves for official positions. It is this spirit that is predominant in the success of Mining Extension.

THE WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION

By Henry G. Knight,

Director and Chemist of Agricultural Experiment Station

The West Virginia Agricultural Experiment Station was established in 1889 as a result of an Act of Congress appropriating Federal funds for the maintenance of experiment stations, primarily for the investigation of problems concerned with the agricultural industry, in each of the several states. In most states the experiment stations have been organized as adjuncts to the Land Grant Colleges, and this is the case in West Virginia.

The primary object of the experiment station as already stated, is to secure information which will benefit agriculture by the study of agricultural problems. A secondary object of no less importance is to influence the farmers of the State to adapt their practices to conform to the best methods which the research may establish. This latter object is accomplished through the publication of results of research in the form of bulletins and circulars which are distributed free to farmers throughout the State and by more direct personal contact through the medium of the extension forces whose duty it is to take the work of the station directly to the farmers and then to encourage the adoption of improved methods of agriculture.

During the period of its existence the West Virginia station has had a direct influence on the agricultural practices of the State in many ways, which can be specifically pointed out as well as an intangible influence making for progress which is less readily apparent but none the less real. The station has encouraged the introduction and cultivation of crops not formerly raised in the State such as cowpeas, soybeans, alfalfa and others: it has standardized the varieties of old crops to a degree by pointing out those which were best adapted to the conditions of the State, it has stimulated the use of fertilizers and determined methods of culture best adapted to the various crops. In the field of horticulture it has made available to the fruit growers information of a similar nature and has also taught them how to prevent injury to the fruit from diseases and insects and how to pack and market fruit and how to best prune trees. In fact, it would be extremely difficult to estimate just how much the

station has had to do with the development of the tremendous fruit industry of the State which has reached its most extensive proportions in the Eastern Panhandle. The less spectacular potato industry, the most important phase of truck crop raising in this State, has received its share of attention from the station and has reaped its proportional benefits.

The livestock industry presents problems of an entirely different nature from those of crop production but these have not been neglected. Cattle, hogs, and sheep, the main classes of livestock in this State have been studied, especially from the point of view of determining the best feeding methods and the best means of improving the quality of the animals. A direct and very visible result may be seen in the rapid replacement of scrub animals by herds and flocks of pure bred or high grade stock. The encouragement of the use of pure bred sires has been largely responsible for the improvement and it has been one of the accomplishments of the station. Much of the area of West Virginia is better adapted to sheep raising than to any other branch of agriculture and the encouragement of this industry has long been one of the concerns of the station. Dairying, long neglected, is gradually being built up into a major industry and the results of experimental work deserve a large share of the credit.

Poultry raising, formerly a side line on the farm, has developed into a major industry almost directly as a result of the dissemination of information as to breeds of chickens best adapted for egg production and as to proper feeding, housing and management of flocks. Possibly the improvement in this industry may be cited as amounting to an outstanding accomplishment of the experiment station.

One of the reasons for a lack of prosperity on farms has been the fact that while many farmers were experts in producing crops, they lacked the business training necessary to enable them to market those crops to advantage. The experiment stations of the country have recognized this difficulty and have taken up the study of economics as applied to the problems of the farmer and the result has been the development of a new science of Farm Economics. Studies in the management of farms to determine which crops are most profitable and how to eliminate unnecessary sources of loss in farming operations; what machinery to use, and many other similar problems on the farms are now in progress. The problem of marketing including the related problems

of packing and storage, is also receiving attention and information has already been secured which should prove of value.

Allied to the subject of farm economics is rural sociology, another new subject whose origin may be attributed to the experiment stations of the country. Its object is to study any problems which may contribute to the betterment of living conditions in rural communities, much along this line has already been done and more is in progress. The summary of what has been done indicates the present lines of work in the experiment stations. Methods which were new and the best available ten years ago are giving way to still newer and better methods and it is the aim of the experiment stations to promote steady progress rather than to consider that its work is done when a certain point has been reached.

The physical equipment of the station includes offices and laboratories in the Agricultural College and five farms near Morgantown which it operates primarily for experimental purposes. It has also two large farms near Wardensville known as the Lawrence A. Reymann Memorial Experimental Farms, which are devoted to breeding investigations with dairy cattle.

It maintains at Lewisburg, in co-operation with the United States Department of Agriculture, a branch station for the investigation of beef cattle problems and at Maggie has a substation for the investigation of tobacco culture. It has access to the community fruit packing plant at Inwood in Berkeley county and this serves as a center for the fruit experiments which are carried on in co-operation with various fruit growers. Co-operation with the farmers in all lines of work is practiced extensively and forms a most satisfactory means of extending the facilities of the station when its own farms are unable to offer the conditions necessary for the work to be done.

The demands of agriculture for information along all lines are becoming so great that it is recognized that the experiment stations will not be able to meet them all successfully unless means are found for increasing the funds devoted to experimentation and research. In consequence during the past year a special study has been made of the needs of the field with a view of formulating plans for the development of the research of the Agricultural Experiment Station along lines which will best serve the interests of the State. Committees representing the various agricultural interests have been appointed by the several State

agricultural organizations and they are devoting their attention to special phases of the work. Although preliminary hearings only have been held it is very evident that there is a unanimity of opinion that the major lines along which the experiment station has been devoting its energies should be continued with minor changes only, while more attention should be given to special phases of farm economics and rural sociology.

The desire and willingness of farmers in all parts of the State to assist in the work of the station gives the most flattering evidence of the esteem in which they hold the experiment station established for their benefit.

THE UNIVERSITY AND WEST VIRGINIA COMMUNITIES:
CAN WE CO-OPERATE AND HOW?
THE UNIVERSITY VIEWPOINT*

By Nat T. Frame, Chairman University Extension Committee

*Address delivered during "Cities Week," Morgantown, March, 1924.

The co-operation that the University gives to West Virginia communities by educating, at the University, the future leadership of these communities is in general well understood and is not the topic under discussion at this time.

Somewhat gradually in recent years the University has been developing a type of co-operation with the communities not so well understood by the State at large. The University departments of education and history have conducted extension courses in Parkersburg, Wheeling, Bluefield, and other communities of the State, by means of which non-resident students have been enabled to earn definite credits toward degrees. The branch summer school last year at Bluefield was another definite University activity off the campus.

An outstanding piece of University work, probably the best of its kind in the United States, is the mining extension courses conducted in a number of different mining communities in various parts of the State, including the special short course on the University campus.

Other members of the staff of the College of Engineering have acted in an advisory relationship to the Road Commission and to various municipal projects in the State covering many lines of activity, and giving to these communities the benefit of the technically trained men at the University.

The kind of co-operation rendered by the University athletic department, through its publicity service, its schools for coaches, its general stimulation of intercollegiate and interscholastic athletics, and by the University alumni association through its personal contacts with the alumni in practically every community in the State, have made of Adam Stansbury and Roy Yoke such well-known personalities that each is practically an institution unto himself.

Real co-operation was rendered the newspapers of the State by the two conferences of editors held under the auspices of the

courses in journalism at the University. Definite service is also constantly being rendered to the newspapers of the state through the editor of the College of Agriculture.

The fifth annual West Virginia high school literary contest to be held under the auspices of the University Saturday, April 12, 1924, is stimulating interest in several score communities in the state in debates, essay, oration, reading, and extemporaneous speaking.

Dramatic groups and debating teams, trained in the department of public speaking at the University, going out to the various communities in the State to put on plays and to stage debates for the benefit of local audiences, was another help to various communities.

The package library service recently inaugurated by the University librarian has already provided several hundred packages of clippings and other references for use by high school students, women's clubs, and other groups. The demand for this service is steadily increasing.

Under the auspices of the department of sociology groups of students aided by the Y. W. C. A. and the Y. M. C. A. are rendering actual social service in Scotts Run and other communities.

Co-operating with the Better-Homes-in-America movement, members of the University faculty and representatives of the extension staff are this spring assisting a number of communities in West Virginia with their model cottages.

Last year under the direction of a member of the faculty of the Medical College postgraduate medical courses with clinics and lectures on the diseases of children were conducted in Morgantown, Fairmont, Clarksburg, Weston, and Buckhannon. The success of this venture warrants two circuits this coming season—one on internal medicine, covering Morgantown, Fairmont, Clarksburg, Weston, Parkersburg, and Moundsville, and the other on children's diseases, covering Williamson, Welch, Bluefield, Charleston and Huntington.

Business institutes of four days each, under the auspices of the professor of business administration of the University department of economics, with the aid of specialists from outside, were conducted last fall at Clarksburg and Fairmont.

Under the guidance of the professor of industrial education, College of Engineering, four weeks' schools of retail salesmanship have already been conducted in Morgantown, Fairmont and

Huntington, and plans made to carry the same movement to other cities.

The extension work in agriculture and home economics in which the University is a partner with the United States Department of Agriculture and the county farm bureaus, has assisted about two hundred country communities in scoring themselves, in carrying on campaigns for community improvement to advance the standards of community living, thus raising the community score. The community program of work resulting from these scorings and from other activities of the extension division are each year combined in the various counties into county programs of work and in January of each year these are again combined into a State program of country-life development. In this particular field of work a rather distinctive plan now nationally known as the West Virginia Plan has evolved.

The success of the scoring method with the smaller country communities led to a demand from the cities for comparable help from the University.. To meet this the University Extension Committee was appointed and members of the University faculty serving on this committee have already assisted Morgantown and Buckhannon in scoring themselves and working out balanced community programs for improving conditions and so raising their scores.

A score card for use in industrial neighborhoods, including mining camps, has also been successfully used.

This score card method of approaching community problems even in the cities and in industrial centers is opening up a very broad field of usefulness to all departments of the University, and already requests for this kind of service from the communities is more than the present University extension committee can care for.

There are three extension centers under the administration of the University with definite land and buildings not a part of the campus. These are the Four-H State Camp of 96 acres at Jackson's Mill, the Demonstration Fruit Packing Plant of five acres at Inwood, and the Kanawha State Park at Dunbar near Charleston where one hundred and twenty-six acres are under lease for fifty years. Jackson's Mill is not only used for a series of Four-H Camps through the summer season, but also is the training camp for the University football team and is the winter school for country youth who have not had an opportunity to come through the regular high school courses to the agricultural college. The

Inwood Packing Plant is also an extension school where apple packing and marketing methods are demonstrated, and at the Kanawha State Park is being set up an exposition where the standards that go to make the 1000-point community will be visualized as exhibits, models and demonstrations.

REPORT ON STUDY OF MORGANTOWN WATER SUPPLIES

By Willard W. Hodge,

Professor of Chemical Engineering,
West Virginia University.

Note:—When it was suggested that a paper on a water supply for the University would prove a very desirable article for the "Bulletin," it was learned that Professor W. W. Hodge had already prepared such a report under date of June 16, 1922, and placed the same on file with the President of the University. Through the kindness of President Trotter this report was immediately placed in the hands of the editorial committee for the Bulletin for such use as they might wish to make of it. The following is the essential part of the report, giving data of interest not only at Morgantown but also, since the Monongahela River is quite typical of the industrial rivers of West Virginia, of interest throughout the State.—Editorial Committee.

OUTLINE.

Introduction.

Sanitary Analyses, Morgantown City Water.

Bacteriological Tests.

Nitrogen Determination as Ammonia.

Tastes: Chlorine and Chloramines.

Turbidity and Sediment.

Chemical Analyses.

Total Solids and Mineral Content.

Hardness, Temporary and Permanent.

Reaction.

Permunit Tests on Morgantown City Water.

Effects of Certain Industrial Wastes.

Deep Well Water.

Comparative Costs.

Shallow Well Water.

Corrosion Tests.

Tabulation of Analytical Data.

General Application.

INTRODUCTION

The following discussion relative to better supply of water for our University needs is based on the results of nine complete analyses of the Morgantown city water, two analyses of deep well water from the Madeira Hotel well, one analysis of a shallow well water from Professor George W. Grow's well, and four analyses of city water after it had been passed through a Permutit filter. The samples of city water were collected on different days over a period of five months to obtain data as to the variation in the chemical content of the Morgantown city water.

MORGANTOWN CITY WATER. SOURCE,—MONONGAHELA RIVER

Sanitary Analyses. The bacteriological tests were made by Dr. Aaron Arkin of the Medical School with the following result: the bacterial count is generally very low and the water is usually safe for drinking purposes. These bacterial tests should be made every day. At present, Mr. Beckett, Assistant Sanitary Engineer, from the State Health Department, is making daily chemical and bacteriological tests on the city water, thereby securing a much better control on the chemicals used and the time of treatment. Since he has taken charge of the work at the filtration and pumping plant a much more satisfactory supply of water has been available in Morgantown than was previously the case.

***Ammonia Content.** We ran tests for free ammonia which were all negative. For albuminoid ammonia the results were fairly constant, running from .15 parts per million (p.p.m.) on November 5, 1921 to .19 p.p.m. on December 8, 1921. Total nitrogen as ammonia ran from .65 p.p.m. on November 5, to .89 p.p.m. on December 8. Wanklyn* states, "0.10 p.p.m. of albuminoid ammonia begins to be a suspicious sign; and over 0.15 p.p.m. ought to condemn a water absolutely. This is, however, too hard and fast a rule for general application, especially to brown or peaty river waters in the Eastern United States."

*Analytical Methods used throughout this investigation were those given in: Standard Methods of Water Analysis of the American Public Health Association, 1920 Edition, and in Stillman's Engineering Chemistry.

*Mason—"Examination of Water"—p. 81.

Tastes: Free Chlorine and Chloramines. The Morgantown city water has at times a disagreeable taste said by many people to be like chlorine. Therefore, tests were made for free chlorine and chloramines. Tests for free chlorine in Morgantown city water gave negative results. Tests for chloramines, while not developing during the usual time limits, did develop positive color on longer standing. Especially was this true on days when the water tasted badly and when a sort of milky turbidity could be observed in the water. Recent investigations on chlorinated water supplies seem to indicate that the disagreeable chlorine-like tastes which are often noted in these waters are not often due to free chlorine, but to chlorine acting on organic impurities in the water forming so-called chloramines and chlorophenols.

Turbidity and Sediment. The water as drawn from the faucet often had a slight opalescent turbidity and on allowing bottles of the water to stand for a few days, a brownish-green sediment collected on the bottoms of the bottles. Water passed through the Permutit Filter on these days has been standing in bottles for several months and no sediment has been deposited. In fact, the water looks as clear and good now as when first filtered.

The presence of this sediment in the city water indicates that either the filters at the plant are faulty in construction, are worked too fast or beyond their capacity before cleaning, or that the time allowed for flocculation and settling in the tanks is too short. Since Mr. Beckett of the State Health Department has taken over direction of the filtration plant the water here has deposited very little sediment. It shows a great improvement in this respect over the results we were getting the preceding fall and winter. It seems that the university should exert its influence both for its own protection and as a duty to this community to the end that proper bacteriological, chemical and mechanical control of the water supply be maintained at the filtration and pumping station.* We do not overlook the fact that

*Since writing this report, June, 1922, the local Utilities Company has built and fully equipped at the pumping station a small laboratory in which the necessary bacteriological tests, count, and gas formations, are made twice daily and chemical tests on raw and filtered water every few hours. The company has also installed another large sedimentation tank and another rapid sand filter. The city water supply has been greatly improved through the use of the control tests and if those trade wastes emptied into the river upstream, which are largely responsible for the occasional disagreeable taste in the water, could be disposed of in some way other than by being run into the Monongahella River the city water would be a very much more satisfactory, potable water than it was at the time of writing this report.

starting with such water as Monongahela River supplies, the plant generally does good work, but careful scientific tests and control are essential to our receiving the best water possible, considering the source of supply.

Total Solids and Mineral Content. One of the bad features of the Morgantown city water is the wide variation in total solids and mineral content. Of course, more or less variation has to be expected when using an industrial river like the Monongahela as a source for the water supply. The following data selected from the many analyses made shows clearly the wide variations which occur in the mineral content of the city water. The figures are given in parts per million (p.p.m.) which is the present accepted standard in the United States for reporting water analyses.

Total solids varied from 72.7 p.p.m. on November 5, 1921 to 166.4 p.p.m. on January 5, 1922 and was down to 77.2 p.p.m. again on March 15. The residue on evaporation for total solids was a dirty yellowish brown, an indication probably of organic matter or iron compounds. Aluminum, calculated as aluminum sulphate, varied from a trace on January 3, 1922 to 36.8 p.p.m. on November 14, 1921. Iron varied from traces on November 4 to 18.3 p.p.m., calculated as ferric sulphate, on January 3. Calcium, as calcium sulphate, was as low as 25.0 p.p.m. on November 24 and up to 77.5 p.p.m. on December 7 and 8. Magnesium, calculated as magnesium sulphate, varied from 2.6 p.p.m. on November 24 to 12.9 p.p.m. on January 3. Sodium and potassium, as sulphates, ran from 16.2 p.p.m. on November 5 to 59.3 p.p.m. on January 3. Chlorine combined as chlorides, was fairly constant, varying only from 3.2 p.p.m. to 3.5 p.p.m.; an analysis reported two years ago gave 8.0 p.p.m. Sulphate, as SO_4 , varied widely from 32.9 p.p.m. on November 5 to 99.1 p.p.m. on January 3. The above comparisons indicate clearly the variable nature of our city water. The amounts of calcium and magnesium, and sulphates are always too high for the best boiler, laundry, or personal use water.

Hardness. Temporary hardness was practically nil. Only occasionally was there a trace of this type of hardness detected. Permanent hardness, which is possibly the more detrimental of the two, ran high in all our analyses. The lowest was 31.6 p.p.m. on November 24. The highest was 71.2 p.p.m. on January 3. This is the type of hardness which is not removed by boiling the water. It is a soap consumer forming the disagreeable scum

(insoluble soaps) when soap is used in the water. It is caused by the calcium and magnesium sulphates and chlorides present in the water and these salts are among the worst offenders in forming scale in boilers and in hot water pipes.

Reaction. The water was occasionally acid to phenolphthalein but usually neutral or slightly alkaline to methyl orange. On January 3 the water showed 7.8 p.p.m. acidity to methyl orange. Any such condition as this causes very rapid corrosion of iron pipes, especially if they are hot water pipes.

Permutit Tests. To determine whether the city water could be made satisfactory by the Permutit Process, a number of experiments were carried out using the Permutit filter which the Permutit Company kindly presented to our department last year. The analyses made on the water after it had passed through the filter showed that practically all calcium, magnesium, and iron salts had been removed. It is the salts of these elements which cause most of the scale in boilers and form scum when soap is used in the water. By this Permutit Process the city water was greatly improved for all drinking, laundry, and personal uses. Also the removal of the scale-forming ingredients and acidity made the water much better for hot water pipes and power plant purposes. A comparison of the maximum and minimum mineral contents of samples of this filtered water is given in the tabulation on a later page. The filter was also run at three times the rating and to over twice the total capacity before regeneration, but in none of the tests did we find appreciable amounts of the injurious compounds in the filtered water. While it would not be good practice to constantly overwork a filter to such an extent, still this experiment proves the suitability of the Permutit Process to our conditions, for the filter automatically adjusts itself to take care of wide variations in the mineral content of the feed water, in this case the Morgantown city water.

Effect of Certain Industrial Wastes. During the last summer (1923) tests were carried on in an effort to determine the sources of the disagreeable taste at times present in the water from the Monongahela River. The waste materials run into the river in the Fairmont district and above appear to be largely responsible for the bad taste, the large quantity of phenolic and tarry waste material from the by-product plant at Fairmont being probably the worst contribution. The by-product company has taken steps that in the future may lead to the removal

of this source of pollution of the river water. Work is also under way to secure a larger proportion or the whole of the Morgantown city water from the Tibbs Run area. Because of the expected improvement in the city supply no steps have as yet been taken to secure for the University a supply from deep wells. The report on the deep well water follows.

DEEP WELL WATER—MADEIRA HOTEL.

The late Professor B. H. Hite made a sanitary analysis of the water from this well some years ago which gave the following results:

	Parts per million		Parts per million
Nitrites	0.0.	Sulfuric anhydride	2.74
Nitrates	0.17	Iron	trace
Chlorine	33.00	Free Ammonia	0.076
Oxygen consumed	4.30	Albuminoid Ammonia	0.038
Soap hardness	10.00	Bacteria per cc.*	8.
Permanent hardness	0.00	Colon bacillus*	not found
Alkalinity	146.97	Suspended solids	none
		Total solids	218.00

The water is evidently a very good potable water. He, however, did not determine the nature of the total solids which ran high, 218.00 p.p.m. These would be prime factors in considering the water for boiler, laundry, and personal uses. We, therefore, ran a complete analysis for the mineral contents on a sample of this Madeira well water. In this sample the total solids were somewhat higher than in the analysis reported above, perhaps accounted for by being made during a drier season.

Determination	Parts per Million	Determination	Parts per Million
Soap hardness	9 to 12	Iron	trace
Chlorine combined	19.1	Silica	3.1
Sulphates	none	Total solids at 300°C	262.7
Calcium as CaCO ₃	7.85	Alkalinity as NaHCO ₃	372.0
Magnesium as MgCO ₃	7.25	Sodium as Na ₂ CO ₃	234.0

The residue on evaporation for total solids was a clean white deposit indicating probable absence of any appreciable amount of organic matter or iron compounds. The water as drawn from the well was neutral to phenolphthalein. From the analyses and tests one would judge this water to be exceptionally good for laundry and personal uses and far ahead of the Morgantown city water for drinking purposes and as a boiler feed water.

Mr. Madeira states that they have been using this water for all drinking, bathing, laundry, and boiler purposes at the hotel for the past twenty years with most satisfactory results. They

*The bacteriological tests were made by Dr. N. J. Giddings.

have never had any trouble with rust in the hot water pipes when using their well water. When the hotel last fall replaced their old boiler with a new larger sized boiler, the old one was still in good condition after over twenty years of use. The boiler in Mechanical Hall after only occasional use over a like period of time, but using city water as feed water, had to be scrapped and replaced by a new boiler last fall. Of course the hotel boiler was a low pressure boiler, while the one in Mechanical Hall carried high pressures, but results with the same kind of feed water would be similar since it is the heating of the water up to and just past the boiling point which frees dissolved gases and causes the increased chemical activity of the compounds present as impurities in the water. As to the value for drinking purposes, the Madeira well water is far ahead of our city water both as to taste and nature of mineral content. This deep well water would be well suited to all our university needs. Comparative data are given in the tabulation on a later page.

From the standpoint of adequacy of supply, Professor S. B. Brown states that all the geological evidence indicates an abundance and unfailing supply in the underground water reached by the Madeira well. He states that at present there are four other wells in Morgantown drawing on this same vein of water. With all these wells pumping their maximum the lowering of the surface level of this underground water is so slight that the quantity of water would also undoubtedly furnish a supply sufficient for university needs. It might be necessary later, if too many people began drawing on this source, to have some city ordinance passed protecting the prior right of the first users, but at present this source of supply appears to be ample for all University requirements.

The Madeira well is 620 feet deep. The depth of a well on the University grounds tapping this same water-bearing stratum would depend on where the well was placed on the campus. Professor Brown states that the water might rise in the well to within 60 to 160 feet of the surface, again depending on the location of the well. The vein of conglomerate that bears the water comes to the surface at Dellslow Creek Crossing and is there twenty feet below the level of Woman's Hall. If these geological indications are correct, as in all probability they are, the driving of deep wells for the University water supply offers the best solution of the problem. In the long run it would also

prove the cheapest. Further, the providing of such a fine water supply for the University would have certain publicity value as to safeguarding the health of the students while they are here.

Comparative Costs. We were not empowered to solicit bids, and it is difficult to secure careful estimates unless the business is actually in sight, since labor and machinery costs are changing rather rapidly at the present time. We are informed that some years ago it cost \$3100 to drill and equip the Ice Plant well. This is located on a level about 100 feet lower than Woman's Hall. Mr. L. G. Hoskins states that he is ready to drill these deep wells for \$2.50 per foot, which would mean \$1500 for drilling a six hundred foot well. Costs of casing for the well, pumps, piping, storage tank and machinery for the successful pumping and distribution of well water would depend on the size and quality of the machinery installed. The regular city water could still be used for fire protection, flushing toilets, sprinkling the campus and watering the green house crops. However, the wells drilled and tapping this stream of water in the so-called salt sands strata are reported to deliver from one to three barrels of water per minute. If we should strike a well from which one to three barrels per minute could be pumped one such well should take care of all University requirements for some time to come. Installation of a Permutit Softener would probably be at lower first cost than the well and equipment, but definite comparative cost data should be obtained before making a decision.

SHALLOW WELL WATER

A sample of water was secured from G. W. Grow's well. Analysis showed this water was fairly good water, somewhat similar in reaction to that from the Madeira well since it became softened on boiling. It did, however, contain considerably more of the undesirable calcium and magnesium compounds. To sink enough of these shallow wells to furnish a sufficient supply of water for University needs would probably be too costly, and since the indications were that the water to be so obtained would not be as good as the deep well water no further investigations along this line were made.

CORROSION TESTS

A number of corrosion tests were made in connection with this investigation of the local water. The scale removed from two

pieces of old hot water pipe which had to be removed after only about two years service from Woman's Hall was found to consist of 88.80 per cent of iron oxide and 5.70 per cent of moisture. The cause of this corrosion is judged to be the dissolved gases and other chemicals in the city water, (in which on April 5 were found 5.18 c.c. of dissolved oxygen per liter). The report does not include results of analyses of water from the *Fields reservoir as that did not appear as a probable source of supply under the arrangements prevailing at the time this report was written.

*At their February, 1924, meeting, the directors of the local water company decided to secure the entire supply of water for Morgantown from Tibbs Run. Dr. R. P. Davis, head of the Department of Structural and Hydraulic Engineering in West Virginia University, had presented a report on the proposition which showed that by constructing a large reservoir at Fields Lake the run-off from the Tibbs Run and certain adjacent water sheds would be sufficient to meet Morgantown's needs. Consequently a complete examination is being made of the water from the present small reservoir at Fields Lake. Results so far indicate that: (1) the water will have to be chlorinated to bring the bacterial count down to within the limits set for safety by the State Department of Health; (2) the total solids in this water is only about one-fourth that of the average in the present water supplied to the city; (3) soap hardness is less than one half that of the present supply; (4) loss on ignition about the same as the present supply. This last indicates that proper precautions will have to be taken to prevent the growth of objectionable algae and other micro-organisms in a large reservoir filled with surface water. This Tibbs Run water is evidently a much better water for all drinking, personal, laundry, and power plant purposes and will be far less variable in content than the present city water supply taken from the Monongahela River burdened with its load of industrial and municipal wastes.

TABLE

Comparative study of the sixteen analyses made.

All data are given in parts per million.

Thanks are due to Mr. W. T. Kramer, Chemist for the State Road's Laboratory, who co-operated fully in the analytical work embodied in this report.

	CITY WATER		PERMUTIT WATER		Madeira Well	Grow's Well
	Minimum	Maximum				
Total Solids.....	72.7	166.4	165.8	173.0	262.7	126.0
Silica.....	4.7	6.2	4.3	5.4	3.1	
Aluminum as $Al_2(SO_4)_3$	trace	86.8	7.7	11.15		6.6 (Al_2O_3)
Iron as $Fes(SO_4)_3$	trace	18.3	nil	nil	trace	
Calcium as $CaSO_4$	25.0	77.5	nil	nil	7.85 as carbonate 1.25 as carbonate	71.5 as carbonate 28.6
Magnesium as $MgSO_4$	2.6	12.9	nil	nil		
Sodium and Potassium as Sulphates**	16.2	59.3	156.6	163.0		58.0 as sodium carbonate trace
Chlorine, combined.....	3.2	3.5	3.1	3.3	19.1	trace
Sulphates as (SO_4)	28.0	99.1			nil	trace
Temporary Hardness as $CaCO_3$	nil	145.0	nil	nil		48.4
Total Hardness as $CaCO_3$	36.1	71.2	nil	nil	9 to 12 soap hardness	114.0
Acidity as H_2SO_4 Phenolphthalein	2.5	29.4	nil	nil		
Acidity as H_2SO_4 Methyl Orange, actual Acidity.....	Neutral	7.8	nil	nil		
Alkalinity as $NaOH$	nil	nil	0.9	1.0	372 as	$NaHCO_3$

*Evaporation in Pyrex glassware may have increased slightly the silica content.

**Probably about half present in the city water as chlorides.

GENERAL APPLICATION

With the ever increasing development of West Virginia as a mining and industrial State the question of suitable water supplies for institutions, city, and factory purposes becomes of great importance. We have about reached the point where the citizens of the state must decide whether the larger rivers are worth more to the common welfare as carriers of city sewage and industrial wastes or as sources for city water supplies and for recreational purposes. It seems probable, since the continued growth and prosperity of our commonwealth depends so largely on the success of the mining and manufacturing industries in the State, that our large rivers will be most valuable for the first purpose mentioned and that the cities will have to look to other sources for their supplies of potable water.

As shown in this report the high albuminoid nitrogen content of the Monongahela River water indicates that the sewage wastes being emptied into the river above Morgantown must soon be limited in quantity if the river water is to be "self purified" by

the time it reaches Morgantown. Also, the bad tastes are caused by certain industrial wastes some of which cannot be removed by any known practicable method. Consequently Morgantown is to change the source for its city water supply from the Monongahela River to Tibbs Run and deep wells. This will involve an additional expenditure of over two hundred thousand dollars. It is probable that other cities will sooner or later have to make similar changes unless suitable legislation is enacted whereby the State Department of Public Health shall be given the duty of supervising the kinds and quantities of waste materials dumped into the public's rivers. This department should also be given the power to limit or prohibit the running into a stream of such waste materials as are seriously detrimental to municipalities or larger industries farther down the same stream, always with due consideration for any "priority rights" of the companies or cities affected. Especially are these measures necessary when there is no known method of neutralizing or removing from the river water the offensive substances. Only in this way can the rivers of the state be of the greatest service to all and the public health be duly safeguarded.

A STATISTICAL STUDY OF FIVE HUNDRED AUTOPSIES

By W. A. Smith,

Professor of Pathology and Bacteriology

The last 500 autopsies performed at Willard State Hospital, New York, have been reviewed more especially for the purpose of observing how the pathological lesions causing death differ in the different psychoses. It was found necessary to discard the records of ten cases because, in some instances, a positive diagnosis of the psychosis could not be made, while in other cases, no anatomical changes were discovered at the autopsy. Six

*Editorial Note: The figures which form the basis of this paper were collected by Dr. Smith during a service as pathologist of five years at Willard State Hospital, New York. Over 400 of these autopsies were conducted by him personally. Though the data presented by Dr. Smith in this paper are somewhat technical and of primary importance to the medical profession, we feel that they will also be of interest to many other persons, because of the increasing interest and knowledge of medical matters prevalent at the present time.

The persons whose deaths are recorded in this paper were all inmates of a State Hospital for Insane persons and show conditions comparable to those in such an institution anywhere. It is of interest to observe that the mental troubles of these patients are classified into types just as definite as the diseases of the body with which we are familiar. There is every reason to believe that these mental defects are but manifestations of certain physical defects, which in time will be definitely recognized and treated for the relief of the mental symptoms. In only one small group of patients, those suffering from general paresis, a preventable disease, are a high percentage of deaths due to the mental disease which brought the patient to the hospital. In all the other types of mental diseases, the patients lived to a fairly advanced age and after residence of several years in the hospital nearly all died from other diseases, such as are responsible for death of any person of about the same age. The proportions of the various causes of death are, however, somewhat different from those of aged persons of the general population, partly, because the necessary conditions of life within an institution are different from that outside, and partly, as Dr. Smith points out, because of apparent relation between one mental disorder and a certain disease, as indicated by the very high mortality from tuberculosis among those suffering from adolescent insanity.

The fact is clearly brought from Dr. Smith's tables that insanity of itself seldom brings death, but allows the patient to live to a mature age as an individual worse than useless, a grief to the family and an expense to the family or the public. This fact ought to be a sufficient stimulus to activities looking toward the prevention of this condition.

A feature of interest in this series of cases, is the fact that the causes of death are definitely known from examination of the body after death, the examination in nearly all cases including microscopic as well as gross study. It seems highly desirable that there should be a much wider use of this means of learning definitely the causes of death, especially in those cases in which the cause was not wholly clear to the attending physician. The information so gained would add to the certainty of diagnosis, and the effectiveness of treatment. The natural reluctance of many persons to permit autopsies would be largely overcome if the usefulness of the procedure were definitely known to them.

other cases, including three of Huntington's chorea, and one each of traumatic cerebral softening, infestive exhaustive psychosis, and neurasthenia are omitted from the tabulation leaving 484 cases included in the following analysis. Terminal broncho-pneumonia and other terminal affectations are not considered as causes of death, though it may be observed here that terminal broncho pneumonia occurred in 60 per cent of all cases.

DEMENTIA PRAECOX

(Adolescent Insanity.)

There were 205 deaths in this group, at an average age of 56 years following an average State hospital residence of 15 years. From column 1 of the table it will be noticed that the mortality from tuberculosis is strikingly high, 38.05 per cent. This death rate from tuberculosis is 41 per cent greater than in epilepsy and 109 per cent greater than in imbecility, psychoses in which patients who from their habits and surroundings we would naturally expect an equal or greater percentage of tuberculosis and considerably greater than the percentage of deaths from tuberculosis in New York State, which is given by the State Dementia praecox and tuberculosis not due solely to surroundings decidedly greater than among all the other psychoses in this list where tuberculosis is responsible for only 13 per cent of the deaths.

These facts seem to indicate that there is a relationship between Dementia praecox and tuberculosis not due solely to surroundings or habits of patient. Some writers claim that 20 per cent of their cases of Dementia praecox show a heredity of tuberculosis and believe that many cases of Dementia praecox were predisposed to tuberculosis by heredity. Indeed the family histories of admissions last year to Willard State Hospital of Dementia praecox show that 22 per cent have a history of tuberculosis in the parents. However the histories of a group of cases of other psychoses chosen indiscriminately show a percentage of 23, this showing that heredity also plays little part in the causation of tuberculosis in Dementia praecox. Therefore the large mortality rate due to tuberculosis may only be explained by saying there is a peculiarly low power of resistance to tuberculosis on the part of Dementia praecox patients.

Carcinoma plays a comparatively unimportant role in the causation of death namely 3.9 per cent. This percentage is lower

than the percentage in other psychoses except senile, alcoholic and general paresis and is lower than the percentage frequency of carcinoma causing deaths in individuals of normal mentality (5.5%).

SENILE PSYCHOSIS

(Mental disorder of aged persons).

There were 62 deaths in this group at an average age of 76 years after an average hospital life of 3 years.

In this psychosis the most remarkable feature is the absence of carcinoma for according to the normal death rate given by the New York State Department of Health for all individuals as 5.5 per cent, this group should contain 3 carcinomata and from the age of these patients it might be expected that there would be more, especially as epitheliomata are more frequent in later life. It is worthy of note too that the frequency of tuberculosis is higher in this psychosis than is normal. As it would be expected sclerotic diseases are the chief factor causing death forming 61.29 per cent of cases. In this class of diseases the kidneys showed the most constant changes resulting from arterio-sclerosis, chronic interstitial nephritis occurring in 35.5 per cent of the cases.

PARANOIC CONDITIONS

(Insanity characterized by systematic delusions of persecution and grandeur).

There were 35 deaths in this group at an average age of 66 years after an average hospital residence of 11 years.

Infectious diseases it will be seen were the cause of 22.86 per cent of deaths. This is lower than any other psychosis with the exception of general paresis and according to the tables tuberculosis plays a less conspicuous part here than in most other psychoses. From sclerotic diseases we have a large death rate, 57.15 per cent, similar to other psychoses in which the average age at death is approximately the same. As shown, the death rate from carcinoma is very high, viz. 17.14 per cent as compared with the 5.5 per cent mortality rate in individuals of all ages and of normal brains and the 3.29 per cent found in 455 deaths in other psychoses. Four of the carcinomata affected primarily

the liver and in none of these cases was a history of alcoholism obtained.

ALCOHOLIC PSYCHOSIS

(Insanity caused by indulgence in alcohol).

There were 25 deaths in this group at an average age of 67 years after an average hospital residence of 9 years.

The most noticeable fact shown in the study of these is, as has been mentioned above, the absence of carcinomata. Infectious diseases were the cause of death in 32 per cent of cases, one-half of which were due to tuberculosis. Most numerous however of the diseases affecting alcoholics were the sclerotic diseases which caused 60 per cent mortality. This percentage is exceeded by one psychosis only, general paresis, which is of itself essentially a sclerotic disease.

MANIAC-DEPRESSIVE PSYCHOSIS

In the maniac depressive psychosis the average age at death was 67 years with an average duration at Willard State Hospital of 11 years. In this group tuberculosis is conspicuous by its absence, however the average from other infectious diseases is higher than any other psychosis. As this is only a series of 27 cases any opinion regarding frequency of tuberculosis, infectious diseases and carcinoma (which latter in this series is high viz. 11.11 per cent) must necessarily be reserved.

INVOLUTION MELANCHOLIA

(A melancholy state developed in middle age).

There were 32 deaths in this group at an average age of 66 years after an average hospital residence of 11 years. This shows little difference from the result of the maniac-depressive psychosis except for the large mortality rate from tuberculosis, 21.87 per cent.

IMBECILITY

(Feeble mindedness).

Imbecility in the limited series of 11 cases shows a high death rate from tuberculosis, 18.18 per cent, infectious diseases 63.64 per cent and carcinomata 18.18 per cent.

EPILEPTIC INSANITY

In this series of epileptics there are 26 cases. The average age at death was 55 years following an average hospital stay of 11 years. Infections in this series were confined solely to the lungs and were responsible for 38.46 per cent of deaths, the tuberculosis death rate being 27 per cent. Carcinoma occurred in 7.7 per cent of the cases.

GENERAL PARESIS

(Insanity resulting from syphilitic infection).

The general paresis series comprises 31 autopsies. In this affection the average life of the patient in the hospital was one year and four months. These patients' average age at death was 45 years. Pulmonary tuberculosis is present in this group also, occasioning 6.45 per cent of deaths, one case of pulmonary latent tuberculosis was not considered. One of these patients died of a perforated ulcer of the stomach with resulting peritonitis. Another died of strangulative suffocation, and another of a pus infection of the kidney. The remainder, 26 cases, died if we exclude the usual terminal pneumoia, of their chronic meningo-encephalitis.

DISCUSSION OF CASES

Of brain tumors there were six found in the 500 autopsies, four being gliomata, one endothelioma and one lipoma. Of cerebral arteriosclerosis there were 24 cases, 17 causing cerebral softening, and 4 hemorrhage. Three cases were of the diffuse type.

Reviewing the 490 autopsies as a whole it is seen that tuberculosis as a cause of death ranks twice as high as is usual in the normal death rate but if we exclude the dementia praecox cases it will be found that the tuberculosis causes no more deaths among the insane than among the sane.

From the statistics given it will be seen therefore that the main difference shown between the psychoses in cause of death is the high rate of tuberculosis in dementia praecox as compared with the other psychoses.

A ratio of 1 death from tuberculosis to 2 deaths from other causes occurred even in a group of 80 cases of dementia praecox dying between the ages of 50 and 65 years, while a control

group of 46 cases from alcoholic, paranoic conditions, involution melancholia and maniac depressive insanity dying between the same ages showed a ratio of 1 death from tuberculosis to 12 deaths from other causes.

Another point of interest was that among the 80 cases of dementia praecox dying between the ages of 50 and 65 years, 34 per cent of deaths were caused by arteriosclerotic lesions which in 1-3 of these cases affected the cerebrum. A group of 22 cases of maniac depressive insanity and involution melancholia dying at the same ages showed a much higher death rate from arteriosclerosis, in fact twice the number, or 68 per cent of deaths in this group were due to sclerotic lesions and about 1-3 of these were lesions in the cerebrum. Paranoic conditions and alcoholic psychosis showed at the same ages a similarly high death rate from sclerotic lesions.

As a cause of death cerebral softening was present in all psychoses varying from 3.8 in epileptics to 12.5 per cent in involution melancholia and the 100 per cent in cerebral arteriosclerosis.

In the 490 autopsies there were found 47 cases of cerebral softening and 15 cases of cerebral hemorrhage or one case of hemorrhage to three of softening, thus tending to show that a constructive endarteritis is more frequent than the destructive form of arteritis, in the insane.

Carcinoma in this series of autopsies were found to be 20 per cent less frequent as a cause of death than the percentage given by the New York State Board of Health for all ages. This fact is more worthy of attention because the average age of patients in State Hospitals is that age at which carcinoma is most frequent.

Carcinoma however were more frequent than usual in the following psychoses, viz., paranoic conditions, maniac depressive insanity and involution melancholia; it was altogether absent in the alcoholic, senile and general paretic groups.

		Dementia praecox	Senile psychosis	Paranoid conditions	Alcoholic psychosis	Maniac-depressive psychosis	Involution melancholia	Imbecility	Epileptic insanity	General paresis	All psychoses
Number of cases.....		205	62	35	25	27	32	11	26	31	462
Average age of death.....		56	76	66	67	67	66	.....	55	45	.....
Average years in hospital.....		15	3	11	9	11	11	.....	11	1 1/3	.....
Infectious Diseases	Tuberculosis	78	10	3	4	.....	7	2	7	2	113
	Percent	38%	16%	9%	16%	.....	22%	18%	27%	6%	24%
	Empyema.....	3	1	.....	.....	.....	.....	1	.....	.....	5
	Lobar pneumonia.....	21	2	1	2	3	2	2	1	.....	34
	Primary bronchopneumonia.....	1	1	.....	.....	.....	.....	.....	2	.....	4
	Mastoiditis.....	1	.....	.....	.....	1	.....	.....	.....	.....	2
	Gangrene of lung.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1
	Acute endocarditis.....	4	1	.....	1	.....	.....	.....	.....	.....	6
	Acute pericarditis.....	1	2	.....	.....	.....	.....	.....	.....	.....	3
	Enterocolitis.....	7	2	1	.....	3	1	1	.....	.....	15
	Acute septicemia.....	2	.....	1	.....	.....	.....	.....	.....	.....	3
	Acute peritonitis.....	4	.....	1	.....	.....	.....	.....	.....	.....	5
	Abscess of liver.....	1	.....	1	.....	.....	.....	.....	.....	.....	2
	Cystitis plus ascending pyelonephritis.....	3	1	.....	.....	.....	.....	1	.....	1	6
	Acute appendicitis.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1
	Cellulitis.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1
	Total	126	22	8	8	7	10	7	10	3	201
	Percent	61%	35%	23%	32%	26%	31%	64%	38%	10%	43%
Sclerotic Diseases	Arteriosclerosis only.....	3	3	1	.....	2	.....	1	.....	.....	10
	Arteriosclerosis and cerebral softening.....	8	5	3	2	2	4	.....	1	.....	25
	Arteriosclerosis and cardiac softening.....	2	1	.....	1	.....	.....	.....	.....	.....	4
	Arteriosclerosis and cerebral hemorrhage.....	4	2	2	1	.....	2	.....	.....	.....	11
	Arteriosclerosis and pulmonary hemorrhage.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1
	Arteriosclerosis and rupture of coronary artery.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
	Arteriosclerosis and rupture of heart.....	2	3	1	.....	.....	.....	.....	.....	.....	6
	Arteriosclerosis and cardiac dilatation.....	9	1	7	1	2	4	.....	.....	.....	24
	Arteriosclerosis and cardiac valve distortion.....	3	1	1	1	.....	2	.....	1	.....	9
	Arteriosclerosis and aneurysm of aorta.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1
	Arteriosclerosis and fibrous myocarditis.....	1	.....	.....	.....	1	.....	.....	.....	.....	2
	Arteriosclerosis and chronic interstitial nephritis.....	16	22	4	7	5	4	1	4	.....	63
	Arteriosclerosis and infarction of kidney.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1
	Arteriosclerosis and fatty infiltration of heart.....	1	.....	.....	1	.....	.....	.....	.....	.....	2
	Arteriosclerosis and pachymeningitis haemorrhagica int.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1
	Chronic interstitial pancreatitis.....	.....	.....	1	.....	2	.....	.....	.....	.....	3
	Cirrhosis of liver.....	2	.....	.....	.....	1	.....	.....	.....	.....	3
	Chronic meningoencephalitis.....	.....	.....	.....	.....	.....	.....	.....	.....	26	26
	Total	53	38	20	15	16	16	2	7	26	193
	Percent	26%	61%	57%	60%	59%	50%	18%	27%	84%	43%

		Dementia praecox	Senile psychosis	Paranoic conditions	Alcoholic psychosis	Maniac-depressive psychosis	Involution melancholia	Imbecility	Epileptic insanity	General paresis	All psychoses
Tumors	Carcinoma.....	3		6		3	2	2	2		33
	Sarcoma.....	1									1
	Hypernephroma.....	1									1
	Venous angioma.....	1									1
Diseases of Accidental Causation	Glioma.....										4
	Endothelioma.....										1
	Lipoma.....										1
	Total	11		6		3	2	2	2		33
Degenerative Diseases	Percent	5%		17%		11%	6%	18%	7%		7%
	Thermic fever.....	1									1
	Fracture of skull.....	1				1	2				4
	Obstruction of bowels.....	5					1				6
Miscellaneous Diseases	Lye poisoning.....	1									1
	Injury to abdomen.....	1									1
	Asphyxiation.....	1							1	1	3
	Shock (fractured femur).....	1									1
Tumors	Strangulation (food).....	2									2
	Traumatic cerebral softening.....	1									1
	Total	12				1	3		1	1	19
	Percent	6%				4%	9%		4%	3%	4%
Diseases of Accidental Causation	Spinal cord degeneration (ideopathic).....						1				1
	Acute parenchymatous nephritis.....			1					2		3
	Chronic parenchymatous nephritis.....										1
	Central nephritis.....		1								1
Degenerative Diseases	Fatty degeneration of pancreas (diabetes).....				1						1
	Fatty degeneration of liver.....				1						1
	Total		1	1	2		1		2		6
	Percent		3%	3%	6%		3%		8%		3%
Miscellaneous Diseases	Ulceration of stomach.....	2								1	3
	Ulceration of duodenum.....		1						1		2
	Status epilepticus.....								2		2
	Pernicious anemia.....	1									1
Tumors	Pneumocephalus hemorrhagicus int.....								1		1
	Total	3	1						4	1	9
	Percent	1%	3%						18%	3%	3%

*Including eight cases otherwise classified.

BULLETIN
of the
**WEST VIRGINIA UNIVERSITY
SCIENTIFIC ASSOCIATION**

**VOL. II.
NO. I.**



**September
1925**

CONTENTS

	Page
List of Officers of the West Virginia University Scientific Association	2
Programs of the Association.....	3
Editorial Note.....	4
Research as a Career in Engineering.....	5
Blonde and Brunette Characteristics.....	15
Notes on Zoological Work in the Canal Zone.....	20
The Problematic Plt.....	23
Forests and Forestry for West Virginia.....	25
Sulfur in Coal.....	31
The Hydrolysis of Esters in Alkaline Solution.....	40

OFFICERS
of the
West Virginia University
Scientific Association

PAST PRESIDENTS

A. R. Whitehill.....	1914-15
S. B. Brown.....	1915-16
F. E. Emory.....	1916-17
C. W. Waggoner.....	1917-18
B. H. Hite.....	1918-19
A. M. Reese.....	1919-20
Aaron Arkin.....	1920-21
N. J. Giddings.....	1921-22
R. P. Davis.....	1922-23
G. S. Dodds.....	1923-24

OFFICERS FOR 1924-25

President.....	Geo. R. Bancroft
Vice-President.....	M. J. Dorsey
Secretary	J. H. Gill
Treasurer.....	E. R. Scheffel
Program Committee {	A. J. Dadisman
	J. H. Gill
	W. W. Hodge

West Virginia Univ. Lib.
W.
3-8-1926

THE WEST VIRGINIA UNIVERSITY SCIENTIFIC SOCIETY
HELD THE FOLLOWING MEETINGS DURING THE
YEAR 1924-25

October 24, 1924.

Speaker: Dr. G. S. Dodds.

Subject: "Observation in the Panama Canal Zone."

At this meeting plans were developed and committees appointed to arrange for the meeting with the society on November 28, of the persons in the state interested in science.

November 28, 1924.

The November meeting was merged into a state meeting with those interested in science. A program was prepared and papers on several scientific subjects were delivered before the various sections of the meeting.

A business meeting resulted in the formation of the West Virginia Academy of Science.

8:00 p. m. Lecture by Dr. Francis H. Herrick, Western Reserve University.

Subject: "Bird and Animal Instinct and Intelligence."

January 30, 1925.

Speaker: Mr. C. F. Drake, Superintendent of the Filtration Division of the Department of Public Health, Pittsburgh, Pa.

Subject: "Water Filtration as Applied to City Water Supply."

February 27, 1925.

Joint meeting with the Lions Club of the City of Morgantown.

Speaker: Dr. Carl E. Akeley of the American Museum of Natural History, New York City.

Subject: "Africa and the Gorillas."

March 27, 1925.

Speaker: Professor E. R. Scheffel.

Subject: "The Geology of the Wallona Mountains of Eastern Oregon."

April 24, 1925.

Speaker: Professor Geo. P. Boomsliter.

Subject: "Stresses and Strains."

May 22, 1925.

Joint meeting with the University Engineering Society.

Speaker: Mr. Steven Q. Hayes, The Westinghouse Engineering and Manufacturing Company, Pittsburgh, Pa.

Subject: "Super Power and Interconnecting of Systems in the United States."

J. H. GILL, *Secretary.*

EDITORIAL NOTE

The committee in charge of editing and publishing the **Bulletin** of the West Virginia University Scientific Association for the year 1924-25 consists of the following: R. J. Garber, Chairman; M. J. Dorsey, R. C. Colwell, G. P. Boomsliter, and P. D. Strausbaugh. The committee is indebted to Walter C. Schnopp, Agricultural Editor, for aid in editing this bulletin.

RESEARCH AS A CAREER IN ENGINEERING*

By T. D. YENSEN, *Research Engineer,*
Westinghouse Electric and Manufacturing Company

During the past year while you have been "listening in" on any XYZ broadcasting station, I wonder how many of you have given any thought to the intensive, nerve-racking, and heart-breaking work that has been going on behind the scenes in order to improve the service? You have been listening to sounds transmitted by means of microphones of the diaphragm type. You have undoubtedly noticed the unsatisfactory reproduction of certain musical notes and certain instruments, such as the piano. This you know to be due to the natural period of the diaphragm. One of my colleagues has been laboring with the problem of getting around this difficulty. For more than a year he has been so absorbed in the work that it has been impossible to keep him from talking "shop" during the lunch hour, or any other hour. However, his enthusiasm kept us posted on the progress made, one day full of glee, the next day in darkest dismay. Gradually, however, the problem was worked out, so that today you have the satisfaction of enjoying a nearly perfect reproduction. The direct current glow discharge was the solution, but before it was reached, a scientific study of phenomena in nearly all the realms of physics was required. Has it been worth while? Of course it has. If in doubt, ask any radio enthusiast. I could mention examples like this in all fields of engineering. It is typical of engineering research.

However, when you look forward to your engineering career, most of you are thinking of large generation stations, transmission lines, substations, steam and electric railways, and the operation and design of all the various apparatus connected therewith; others may be thinking of the design and construction of large bridges and other structures; of machines for doing the thousand and one things needed today; of building the nation's highways and operating its mines; and may be some are thinking of going into telephone, telegraph, or radio work, or aviation.

*Talk given at an open meeting of Tau Beta Pi, West Virginia University, Morgantown, Thursday, March 27, 1924.

Very few of you think beyond the standard known product in connection with these various lines of engineering and it is perhaps natural that you don't. To begin with you will have to follow in the paths of others until you have become thoroughly acquainted with the territory and know as much about it as your predecessors. But some day, sooner or later, you will wish to accomplish something original, to go beyond the beaten path, to explore the unknown.

In this sense, most of you will become research engineers. You will encounter problems connected with increasing the transmission voltages of transmission lines, of building bridges of unprecedented spans, locomotives of unprecedented speed, power, or efficiency; in short, of doing things a bit bigger, better, cheaper, or quicker than ever before. When confronted with such a problem, one of three things will happen, and perhaps a combination of them all.

(1) You will work out the new design based on established data, and construct the machine or apparatus or structure accordingly, using standard materials, assuming that the constants that were all right for the previous cases will hold in the new case. You will make a test of the finished product and find that everything works in accordance with calculations. This is the exceptional case.

(2) Someone else will not be so fortunate. He will find to his chagrin that his creation either does not work at all, or that it flies to bits the first time he tries it, or that his bridge falls down even before it is finished. This experience calls for investigation as to the causes.

(3) The third engineer will find in working out his design that he cannot accomplish what he wants with the standard materials at hand. His calculations show him that he will need materials of unheard of characteristics.

All three of these engineers are in a sense research engineers, but we ordinarily call them design engineers because they usually confine themselves to design work, and when confronted with problems such as indicated above, they find it economical to call upon specialists to help solve them, specialists who are qualified by knowledge, experience, and temperament to tackle problems of this sort.

These specialists are the research men: research chemists, research metallurgists, research physicists, or research engineers.

Theirs is the job of discovering the new materials needed and to work out methods and processes for making them. It rests with them, just as much as with the design engineers, whether the new product will become a fact. Both fields of activity are essential to progress. Therefore we cannot say that one is more important than the other, but as the research activity on a large scale is a relatively recent development, it can truly be said that the marvelous progress during the last twenty-five years is largely due to the work in the field of scientific and industrial research coupled with the co-operation between the scientist, the engineer and the business man.

As a result of this development the importance of research has been quite universally recognized and the demand for good research men has become sufficiently great to make the field of research inviting—not only because it is a fascinating game in itself—but also because the financial compensation is equal to, if not greater than that in other engineering fields.

It goes without saying, that every student is not qualified to enter the research field. Even if he would devote himself vigorously and earnestly to the task of obtaining the knowledge required, unless he has the research temperament, he is not likely to make a successful research man.

He must be honest, of course; nobody is successful in any line of work unless he has some sense of honesty. Even thieves and robbers have to possess some of this virtue in order to be successful. But in research one must be particularly on his guard, because it is so easy to fool oneself, and thereby others who rely upon him. We are all more or less prejudiced in favor of certain results and unless we be careful we are likely to give more weight to points that favor our particular pet theory than to points that oppose it. If we persist in doing this our conclusion may be all wrong, although it sounds plausible and apparently is supported by the experimental data. The saying that "you can prove anything" is not far wrong if you insert the word "apparently." Honesty in the sense in which the term is used here therefore implies open mindedness and broad mindedness. Orthodox views have no place in research work. What we consider truth today may be shown to be erroneous tomorrow when new methods and more delicate apparatus furnish us with more reliable data.

Resourcefulness and intuition are both very desirable characteristics, but these are to a large extent functions of knowledge and

training and can therefore be acquired, at least to some extent, just as can skill in manipulation of instruments and constructive ability.

Above everything else the candidate for a research position must possess perseverance and patience, abundant supplies of both. Anybody expecting results over night might as well give up at once. Usually, the solution of a simple research problem requires the incessant application of diligent thought and hard work for months, and in the case of more difficult problems, for years. I am personally acquainted with one problem that has been worked on continuously by several men since 1912 for which the total expenditure has already mounted to several hundred thousand dollars, and from which the concern supporting it has not yet received any appreciable returns. The work will probably be continued for several years more, because the man in charge has faith in the ultimate success and has succeeded in convincing the management accordingly. The progress has been so slow that the year has to be used as the unit of time in order to show it. That practical business men are willing to support anything like that speaks well for American Research, and shows that the captains of industry in looking ahead are using wide angled telescopes, and not narrow angle microscopes, in determining the path to follow. This method enables them to see beyond the immediate present, and to sacrifice part of their present profits for the sake of promising future benefits.

But to return to the qualifications of our research man. While right temperament is necessary it is not sufficient. It must be supplemented by the right kind of knowledge and training. What the research worker deals with is nature and natural forces, and in order to deal with these subjects intelligently it is imperative that he possess a thorough knowledge of the fundamental sciences: physics, chemistry, and mathematics. With these three branches, supported by a liberal education as a sub-foundation, he need not worry much about details. Courses in shop work, machine design and in too highly specialized fields may be well and good in some cases, but unless these courses are so conducted as to serve the student as examples in the application of fundamental scientific principles to practical problems they might better be left out. The remark is made so frequently of late by men of prominence as almost to have been an axiom that if they had the opportunity to repeat their college course they would devote their time and

energy to those studies that the college is particularly fitted to give and that cannot be pursued anywhere else under equally favorable circumstances. With physics, chemistry, and mathematics, including in these terms also thermodynamics, mechanics, and dynamics, a student is equipped to enter any branch of engineering and particularly research work. Detailed knowledge of the particular branch of engineering that he chooses can be obtained better and more quickly after he has finished his general course and entered professional life. This method has the advantage that the student does not spend valuable time on subjects that may or may not be of service to him later. It happens very often that a student pursues mechanical engineering in college but switches over to electrical engineering after graduation, or something even more remote. I therefore repeat: do not specialize in college. The fundamental sciences, physics, chemistry, and mathematics and training in applying them are fundamental in any field that an engineering student is likely to enter and will insure him, not only a sure foundation, but confidence and enjoyment both in professional and private life.

Having tried to show in a general way how the research problems arise, and the qualifications most desired in a research man, let us examine a bit more closely what awaits a man who has pursued and finished a college course with the intention of entering the field of industrial research. As he presumably has had no practical experience, it is to his own as well as to his employer's advantage that he become acquainted with the company and its products as quickly as possible. He will, therefore, be invited to spend the first six months or the first year as a special apprentice doing work in the various departments of the shop. This part of his training may not be very pleasant nor very remunerative, but if taken in the right spirit will be very beneficial, as in no equal length of time would he be able in any other way to get as much practical experience. During this time the Research Department will keep its eyes focused on him and if he is of the right caliber he will probably be invited to join the Research Department before he has finished his course, although I believe it would be to his ultimate benefit not to do so. In the Research Department he will be assigned to the division for which he seems most fitted or where the need for additional workers is the greatest at the time. To begin with, he will work as assistant to one of the men in charge of a particular problem. He will very soon have a chance to show what

is in him. Personally, I make it a practice to tell a new assistant that I expect him to follow the methods that we have established until he is familiar with them and knows as much about them as I do. Then if he sees any way of improving them I shall be very glad to talk over with him any suggestions that he has to make, but I am very insistent that he does not make any changes until we have agreed that such change is the best thing to do. I also try to make it plain that we are even more anxious to make use of the man's brains than his hands and feet. One of my mathematics' professors in college had the slogan: "Be scientifically lazy," and I think it is an excellent one to practice. As soon as the assistant shows that he is able to carry on a research problem independently, he is given—as soon as opportunity presents itself—a subdivision of the main problem to carry out in co-operation with the other men working on that problem. From this stage it is only another step to be given charge of a main problem and so on up the ladder. The rate of progress, as in every other field, will entirely depend upon the man's ability.

Now there is an entirely different method of entering a research organization, one that may appeal to some men more than the method outlined. A number of universities give splendid graduate courses, incidentally leading to advanced degrees. The graduate students are expected to do some research work and this may lead to results that are of great commercial importance. As industrial concerns are constantly on the lookout for things of this sort the man who has been working on that particular problem may be invited to carry on the work in the research laboratories of the company interested.

Again, in some cases, a student may make arrangement with an industrial concern to pursue a certain graduate course with the view to joining the concern upon completion of the course. In this case it is common to have the student carry on research work that is definitely related to some problem that the company is interested in.

Under the latter two methods the student will probably enter his professional career under somewhat more favorable circumstances than if he joins the industrial concern directly after graduation. He will be on a distinctly higher plane and will, therefore, probably be able to advance more quickly from the very start, particularly if he has the qualifications necessary for a doctor's degree. In any case, I strongly recommend to all who possibly can

afford it, to spend at least a year taking post graduate work. In most cases, the advantage gained will more than compensate for the extra time and money required. On the other hand, it is highly desirable for the student to spend the summer months every year working with some industrial concern, as this will familiarize him with industrial methods while he is getting his academic training, and thus enable him to adjust one to the other at the most opportune time.

In closing let me briefly review some of the various lines of research carried on by my company in order to show you why it is that a concern manufacturing nothing but electrical apparatus has need for specialists in nearly all branches of science.*

1. *Insulation Research.* Electricity has to be insulated in order to work efficiently, and as the voltages and sizes of machines increase the problem of keeping the current where it belongs becomes more and more difficult. It is a problem involving the study of fundamental principles and the investigation of a large variety of materials and methods of treatment and testing.

The subject of transformer oils has been a live one ever since I can remember and we have a number of chemists and physicists devoting most of their time to this subject at the present time. Moisture, sludge deposit due to high temperature, and means for preventing explosions are some of the most important items.

2. *Turbo-Alternators.* With the high speeds and enormous sizes of modern turbo-machines, 62,500 kv-a., or over 80,000 h. p., in a single unit with the rotor running at 3,600 r. p. m., you can readily imagine the stresses that the rotating parts especially are subjected to. To keep the coils in place and to prevent damage to the insulation has been a very difficult problem. The question of cooling has also required painstaking investigation in the realm of conduction, convection, and radiation of heat.

3. *Magnetic Materials.* Between the time, some forty years ago, when any old iron was used for electro-magnetic apparatus, and today when there is a special magnetic material for every purpose, lies a period of continuous study of a more or less hit and miss variety of the properties of the various combinations obtainable by alloying metals with each other. During the last decade this has led up to a more systematic and scientific study of the more important alloys such as iron-silicon, iron-tungsten, iron-nickel and iron-cobalt alloys. It is hoped that the data thus ob-

*In reviewing this subject I am making use of an outline by Mr. C. E. Skinner in a recent number of the Electric Journal.

tained will help to solve the question as to what magnetism really is, thus enabling us to handle the subject in the same intelligent way in which electricity is handled today.

4. *Moulded Materials.* These include shapes made by means of rubber, asphalt, shellac and similar gums and phenolic condensation products, together with the necessary fillers such as wood flour, asbestos, paper, etc. A wonderful field for the organic chemist! The finished materials are used for all sorts of purposes requiring insulating properties, mechanical strength, stability, and combinations of these characteristics. I shall only mention timing devices for gas engines, noiseless gears, panels for radio outfits, commutators for small motors and, last but not least, aeroplane propellers, the latter being a by-product created by the war.

5. *Iron Plating.* If a shaft for a large generator 12 to 24 inches in diameter accidentally is machined a few thousandths of an inch too small, it is a very serious case. Until recently it would have had to be used for a smaller machine, involving a great deal of extra costly machine work. But now methods have been perfected whereby an adherent coating of iron can be electroplated onto the shaft in such a manner as to be able to withstand the severe strains produced in pressing the shaft on to the armature. Worn automobile shackle bolts and crank pins have been recovered; articles have been coated, forged and case-hardened; even cast iron parts have been successfully coated.

6. *Autovalve Lightning Arresters.* The problem of taking care of lightning discharges in connection with transmission lines is as old as the electrical industry, and can readily be appreciated when we are told that lightning discharge may carry as much as 100,000 amperes which for satisfactory operation must be carried off to ground without interrupting the main line current, through a device that ordinarily will not pass any current at all and that will pass a lightning discharge repeatedly without attention. The problem was finally solved successfully by means of discs placed in piles and separated by means of very thin mica rings. An arrangement like this will pass no current until the voltage per disc reaches about 350 volts. If this is exceeded, it will pass an enormous current without any appreciable increase in voltage, and return to its position as an insulator as soon as the voltage decreases to 350 volts per couple. In this connection, testing outfits have been constructed by means of which 200,000 kw. can be passed through an arrester for one hundred thousandth part of a second.

7. *High Frequency Induction Furnaces.* The generation of heat within the material that is to be melted has great advantages, where pure metals or alloys are wanted. To Prof. E. F. Northrup belongs the credit for having pushed this subject to a successful conclusion. By means of mercury spark gap high-frequency apparatus, he has been able to melt down metals with melting points as high as that of platinum. In our laboratory we have further developed these furnaces and have been operating for a couple of years high-frequency furnaces for melting iron in a vacuum with great success, using for this purpose high-frequency generators. We have produced in this way 25 kg. ingots of the purest iron ever made, and are now preparing to make 100 kg. ingots in the same way for use in radio transformers, high quality instrument transformers and many other purposes where high magnetic quality is essential.

8. *Radio Work.* Everybody is more or less interested in this subject and knows about the latest developments. The most important single item in this line is probably the amplifying devices. Great improvements have been made in the electron and emitting tubes, so that now, instead of having to use tungsten filaments requiring several watts to obtain the high temperature necessary, other metals and oxide coatings are used, that emit electrons at a much lower temperature and require only a fraction of a watt. In connection with these tubes amplifying transformers have been developed to such a state of perfection that the amplification is practically constant over the entire range of audio frequency. This has been made possible by means of the magnetic properties of certain iron-nickel alloys. These developments in connection with the diaphragmless microphone already mentioned should make radio receiving not only a novelty but a pleasure as well. The time is fast approaching when the world will be tied together in such a way that a speaker can be heard by all mankind.

In this connection you may be interested in a discovery recently made by the Norwegian physicist, Prof. Lars Vegard, of the University of Kristiania. After years of study and investigation as to the causes and origin of the Northern Lights (Aurora Borealis, so called) he came to the conclusion that they are caused by electrical rays from the sun passing through a layer of solid nitrogen in the upper layer of the earth's atmosphere. He came to this conclusion because the spectrum of the Northern Lights in addition to containing all the ordinary nitrogen lines, contained a strong green

line not detected in connection with any known substance, and the only explanation that he could conceive of was that it was due to solid nitrogen. He then set to work to verify his deduction in the laboratory. He succeeded in freezing nitrogen (requiring a temperature of 212°C) by means of liquid hydrogen and by bombarding this with electrical rays he actually obtained the identical aurora spectrum in every detail. Now what does this have to do with the radio? Simply this: with an envelope of nitrogen dust surrounding the earth we can understand why it is possible to broadcast by radio all around the earth. The envelope simply acts as a reflector to the radio waves. It also explains why broadcasting is more effective at night than during the daytime: because during the daytime the heat from the sun partly evaporates the nitrogen envelope. Furthermore, it explains why the sky appears blue, it explains the zodiacal light, the twinkling of the stars, and it will undoubtedly lead to simple explanation of the stellar nebulae and the origin of the nebular lines. Here is an illustration of a piece of purely scientific research, the results of which probably were thought to be of only academic interest and yet it clears up some of the most perplexing questions of our everyday life, and enables us to go at things with more intelligence than we otherwise could. It behooves us to be very careful in our criticism of the pure sciences as being of no practical value. As soon as mankind shall get to the point where astronomers and Arctic explorers will be regarded not only as the most far-seeing and far-reaching but also as the most practical of scientists, then practical commercial life will afford even greater opportunities for scientific research than it does today, and I believe that time not to be far distant.

BLONDE AND BRUNETTE CHARACTERISTICS

A STUDY IN CHARACTER ANALYSIS

By J. E. WINTER

In the last few years a growing interest has developed in applied psychology, especially in the field of business and vocational psychology. Books on business efficiency usually lay claim to a sound psychological foundation, and are very positive in their statements. Character analysis as an essential to successful business relations assumes an important place among the topics discussed, and in the case of the popular type of efficiency book the author generally resorts to some modified form of phrenology or physiognomy for a psychological foundation.¹

Among the criteria for the determination of character is that of color of the skin, hair, and eyes. Dr. Blackford lays down the rigid principle that the more an individual approaches a pure blonde or pure brunette, the more will he manifest certain definite traits of character. The pure blonde is always "positive, dynamic, driving, aggressive, domineering, impatient, active, quick, hopeful, speculative, changeable, and variety loving." The pure brunette is always "negative, static, conservative, imitative, submissive, cautious, painstaking, patient, plodding, slow, deliberate, serious, thoughtful, and specializing." Such positive statements invite the challenge of experiment, and the following study was undertaken to test the validity of Dr. Blackford's statements. One important experimental study of this problem has already been published, that of Patterson and Ludgate.²

METHOD OF EXPERIMENT

The judges in the present experiment were members of an advanced class in psychology, all of whom had been given particular instruction in the conduct of the experiment. There were in all twenty-nine judges, nine of whom were women.

Each judge chose two blondes and two brunettes from among his intimate acquaintances, making a total of one hundred and

¹ See Blackford: *The Job, The Man, and The Boss*, by Doubleday Page and Co. Sheldon: *The Science of Business*, by The Sheldon School, Chicago.

² Blackford: *The Job, The Man, and The Boss*, p. 144.

³ *Journal of Personnel Research*, Vol. 1, 1922-23, p. 122.

sixteen subjects. Of these sixty-three were male and fifty-three female. The judges were given sheets of paper containing a list of blonde and brunette characteristics (Blackford's list) arranged promiscuously so as to avoid any suggestion as to what particular traits were supposed to belong to blondes or brunettes. Each subject received a positive (+) or negative (—) mark opposite each trait, indicating the presence or absence of that particular trait in his character.

The accompanying graphs show the results of the experiment. Graph A shows the comparative per cent of blondes and brunettes possessing blonde traits. Graph B shows the comparative per cent of blondes and brunettes possessing brunette traits. The solid line in each graph represents the blondes and the dotted line the brunettes.

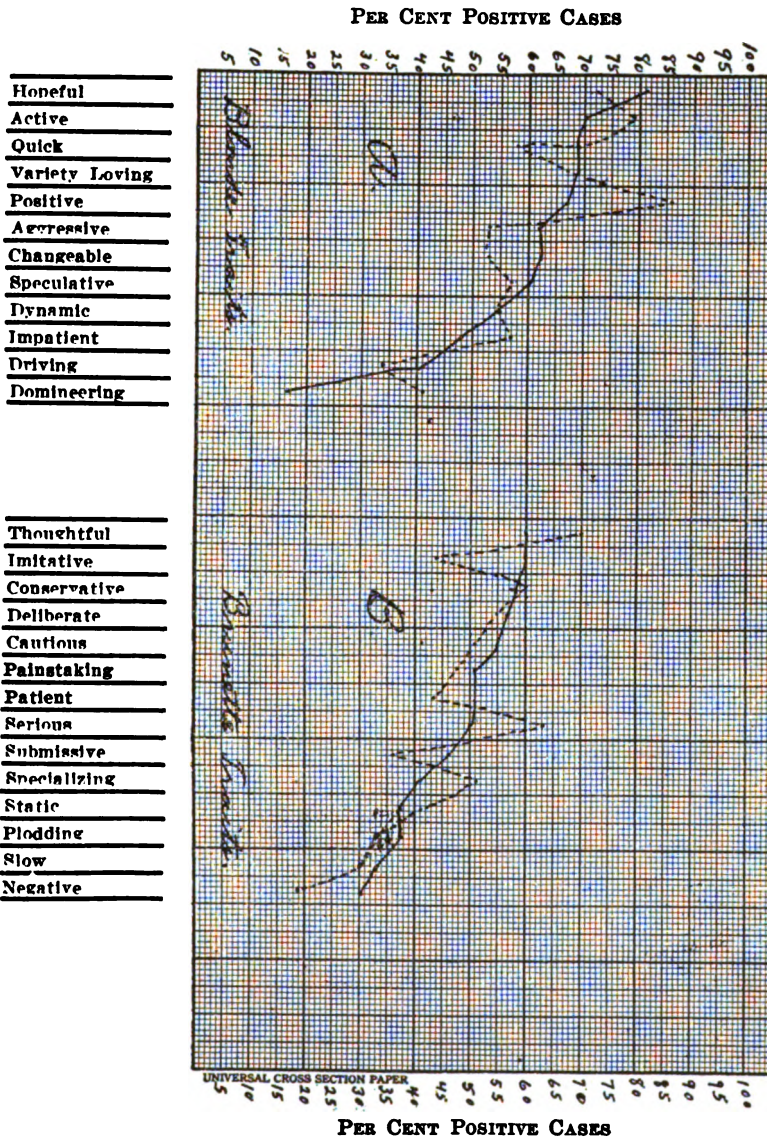
The curves in each graph are arranged in descending order according to the per cent of cases for the various blonde traits.

DISCUSSION OF THE CURVES

If Dr. Blackford's theory concerning blondes and brunettes were correct, in graph A, representing blonde traits, the solid line would be decidedly higher than the dotted line; and in graph B, representing brunette traits, the dotted line would be decidedly higher than the solid line. It will be readily seen that the graphs do not bear out the theory.

In general a high per cent of blondes possessing a blonde trait is accompanied by a comparatively high per cent of brunettes, possessing the same trait. This holds good for the brunette traits also. The actual correlation between blondes and brunettes for all the traits, using the Pearson coefficient of correlation, is $+0.75$. There is, however, considerable variation in the per cent of cases representing the successive traits. From the graphs it would appear that certain traits, such as driving, domineering, plodding, slow, and negative, have no particular significance for either blondes or brunettes. It is interesting to note that the highest score in blonde traits is made by brunette subjects, and the lowest score belongs to blonde subjects. Among the brunette traits the lowest score was made by brunette subjects.

Several of the traits overlap in meaning and thus give the study less range in character analysis than would appear on the surface: for example, plodding and slow; serious and thoughtful; dynamic, driving, and aggressive; changeable and variety-loving.



Blondes—Solid line

Brunettes—Dotted line

A. Shows comparative per cent of blondes and brunettes having blonde traits.

B. Shows comparative per cent of blondes and brunettes having brunette traits.

SEX DIFFERENCES AMONG THE SUBJECTS

In the comparison of male and female blondes, and male and female brunettes, the sex of the subjects seems to play a more important role than color in indicating differences. Male blondes appear to be more thoughtful, serious, positive and deliberate; female blondes are more submissive, variety-loving, changeable, and impatient. Among brunettes the males appear more cautious, static, and speculative; the females are more changeable, quick, and impatient. These sex differences will naturally reduce the correlation between male and female subjects. The actual coefficients of correlation are as follows:

Correlation between male and female blondes + 0.41.

Correlation between male and female brunettes + 0.59.

SEX DIFFERENCES AMONG THE JUDGES

In the comparison of male and female judges certain well-defined differentiating tendencies also appeared. In the case of blonde subjects there was a marked tendency on the part of male judges to ascribe the traits "cautious" and "speculative," while female judges emphasized "specializing" and "deliberate."

In the case of brunette subjects male judges emphasized the terms "patient" and "imitative," female judges emphasized "deliberate" and "slow."

The coefficients of correlation between male and female judges are as follows:

Correlation between male and female judges for

Blondes = + 0.74

Brunettes = + 0.58

Correlation between blondes and brunettes by

Female judges = + .73

Male judges = + .67

CONCLUSIONS

The results of the experiment justify in our opinion the following conclusions:

1. The experiment reveals no plausible ground for Blackford's theory of the relation between color and character traits. This is a virtual substantiation of one of the conclusions arrived at by Patterson and Ludgate.

* Spearman's Rank Diff. Correlation. $P = 1 - \frac{6Md^2}{n(n^2 - 1)}$

2. Sex differences among the subjects play a larger role than color differences in the determining of character traits.
3. Sex differences among judges appear in the particular traits stressed.

NOTES ON ZOOLOGICAL WORK IN THE CANAL ZONE¹

By G. S. DODDS

During the months of June and July, 1924, the writer spent six weeks doing zoological field work in the Canal Zone. The work was done with facilities provided by the Institute for Research in Tropical America, at the laboratory on Barro Colorado Island in Gatun Lake. Barro Colorado Island, which is the largest of those created by the inundation of valleys in the making of Gatun Lake, has an area of more than three thousand acres. It includes a region covered with luxuriant tropical jungle inhabited by a wealth of animal life characteristic of the region. This island, together with the surrounding waters and other accessible land areas, furnishes abundant opportunity for the study of animals and plants where they occur in a profusion unknown in temperate climates. The island has been set apart as a game preserve by the governor of the Canal Zone, and it is planned to make it the center of extensive studies of tropical animals and plants. The importance of such studies is better realized when one recognizes that, more and more, the inhabitants of the temperate zones are looking to the tropics for food supply and for room for expansion.

The Canal Zone is a very favorable region for such work. It is easy of access, and living conditions there are comfortable and without greater danger to health than in most parts of the United States. Every effort is being made to make the laboratory of service to men engaged in the study of all kinds of biological problems. The first annual report, just received, shows that during its first year, thirty-eight persons have done biological work under its auspices, on Barro Colorado Island and in other parts of the Canal Zone.

The zoological work of the writer consisted mainly of a study of the Entomostraca, those minute forms of Crustacea known as *water fleas*, from the fresh waters of the Canal Zone. Collections of these animals were made from all sorts of places throughout the Canal Zone in a preliminary survey of the Entomostraca of the region. A special feature of interest in this work lies in the fact that before the building of the canal there were very few fresh

¹The work which forms the basis for this note was done in behalf of the Museum of Zoology of the University of Michigan. A full account of the collections will shortly appear in the publications of that institution.

water ponds or lakes in the Canal Zone, and that most of those now present owe their existence to the damming of streams in the construction of the canal. Chief among these is Gatun Lake, with an area of 164 square miles and a very long and crooked shore line, made by impounding the waters of the Rio Chagres at Gatun Lock. Of importance also is Miraflores Lake (area 1.6 square miles), which, though at an elevation of 56 feet above sea level, has a distinct saltiness due to sea water which backs up through the basins of the Miraflores Lock.

Only ten years have elapsed since the waters of these lakes and of the canal itself have been established at their permanent level. The present collections of Entomostraca are the first made in the Canal Zone during this interval and the second ever made there. The first collections were those of Dr. Marsh, who, in 1913, published the results of studies of Copepoda made during the latter years of canal construction.¹ In this report he lists fourteen species of Copepods, seven of which are new.

The writer's collections of 1924 include 45 species: Phyllopoda, 1; Cladocera, 30; Copepoda, 14. There was only one new species. The 14 species of Copepoda include 10 of those collected by Marsh and four others. Doubtless all the species in the present collections had been present before the building of the canal, in the few lakes and ponds of the region, but it is of decided interest to learn that, in the few years since that time, they have multiplied greatly and have fully occupied the much larger extent of fresh water now available.

The interest of such collections does not lie alone in the discovery of new species of animals, but in adding information about known ones, and in telling us about the fauna of this particular part of the earth. The intermediate position of the narrow Isthmus of Panama between the two great American continents has long made it of interest as a highway for the migrations of animals and plants between them, and, during the geologic ages, its repeated submergence and reappearance has added to this interest. The Entomostraca of the region, as indicated by the collections of 1924, show that it is in a true sense, intermediate between North and South America, its stronger affinities being with the northern continent.

¹C. Dwight Marsh. Report on Fresh Water Copepoda from Panama, with Descriptions of New Species. Smithsonian Misc. Coll., Vol. 61, No. 3, 1913.

An analysis of the general distribution of the 49 species of Entomostraca recorded from the isthmus is of interest. Nearly half of them are world-wide in their distribution. They show no preference for either colder or warmer waters, being equally at home in tropical lakes of perennial warmth and in those of temperate or sub-arctic regions, which are ice-bound for weeks or months of the year. A somewhat smaller group includes those species which, though they also have a very wide geographic range, are confined to warmer waters, and are found only in a belt about the earth near the equator. A still more restricted group includes those species which are not known outside the American Continent, including (1) certain species which are common all over North America but are unknown in South America, (2) a few others found in South America but extending into North America only as far as the southern edge of the United States, and (3) a few species which are not known outside the Canal Zone, and which certainly have a very limited range.

THE PROBLEMATIC PIT

By A. M. REESE

As is well known, though not as generally known as it should be, the commoner poisonous snakes of North America may be easily recognized by the presence of a deep pit on each side of the head, between the eye and the nostril. This gives to the rattlers, copper-head and moccasin the name of "pit vipers."

The function of this perfectly obvious structure has been a subject of discussion for more than a century and is, to this day, uncertain.

Some investigators thought it was auditory; then it was homologized with the nasal pits of fishes. Others said it was a tear-pit; or a special secreting organ; or an organ connected with the poison apparatus.

F. Leydig, in 1868, after considerable investigation, decided the pit to be an organ of a "sixth sense," related to the mucous canals of fishes. He was sure there was no glandular structure but found several nerves producing a plexus and certain (undescribed) sense organs or end plates.

G. S. West, in 1900, published a paper upon the structure of the pit in which he describes and figures an inner and an outer chamber separated by a thin "pit membrane," the sensory part of the organ. Nerve endings, spindle-shaped cells, mostly on the outer surface of the membrane, were described, the innervation being from the ophthalmic and maxillary branches of the fifth nerve. The membrane, he says, is very vascular and exhibits certain folds.

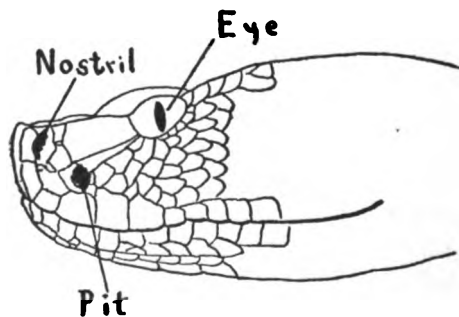
West does not suggest a function for the pit, though he calls it a "tegumental sense organ of the lateral line series." Why he should call it a "lateral line organ" when it is not supplied by a lateral line branch of the fifth nerve and especially as these organs are not found in land vertebrates, is not clear. He thinks a study of the habits of the pit vipers might give a clue to the function of the pit.

Had he known of Parker's work, done a few years later, that proved the function of the lateral line of fishes to be for the perception of vibrations in water too slow to produce what we call sound, he might have hesitated to call the pit of a land animal an organ of the lateral line system.

Percy Viosca (1920), who has investigated especially the enervation of the pit, says it has no structure that would indicate any special, known function. It is not related histologically with the pit organs of fish. He says the peripheral nerve endings of the pit are not structurally different from other endings of the fifth nerve, are of a general cutaneous character, and are homologous to the sensory area of the maxillary branch of the fifth nerve in man.

Viosca thinks his investigations will discard forever the idea that the pit is an organ of a sixth sense. He says, "Since all special sense organs have some obvious anatomical structures which serve to indicate their functional specialization, and as no such structures were observed in any other snakes or reptiles, before any actual investigation was begun I formulated the hypothesis:— that the pit, if it had any significance at all, was merely some modification of an unspecialized structure that could be found in the Ophidia and most probably in the other Reptilia as well. I expected, therefore, to find from the start, negative results with respect to the traditional sixth sense of the Crotalidae."

F. B. Manning, a graduate student at Harvard University, had been carrying on, for a number of years, investigations upon the pit of the pit vipers when his untimely death put an end to his efforts. It is hoped that this work will be completed and published by someone familiar with it, and that it may throw some light upon the function of this mysterious organ



Head of a Rattlesnake showing the position and relative size of pit.

FORESTS AND FORESTRY FOR WEST VIRGINIA

By THOMAS W. SKUCE

The object of forestry is to develop the productive power of true forest land to its fullest capacity. Primarily, this means growing crops of timber on land not more profitably used for something else, and cutting, marketing, and utilizing this timber to the best advantage. It means the controlling of stream flow and conserving of water resources through a protective forest cover on the water sheds. It means the best development and use of forest land for the outdoor recreation of campers, tourists, hunters, and fishermen. It means dollars earned by West Virginia woodland owners and dollars saved by West Virginia timber consumers. It means a home-grown supply of timber assured for the future and the averting of an otherwise probable timber famine.

The need for forestry is becoming so generally recognized and understood that it is necessary only to summarize briefly the outstanding facts. More than two-thirds of the original timber resources of the United States are already exhausted—used, burned, or wasted—and the remaining forests are still being depleted four times faster than a new timber supply is being grown. The forest regions of the world are so situated, and the foreign demands on them so great, that America must always depend almost entirely upon her own timber resources. Unless the public takes immediate action to protect, conserve, and perpetuate the forests of this country, a period of acute timber shortage with its resulting evils is certain to follow. Further delay will result in a serious timber famine, rather than a shortage, in the not far distant future.

West Virginia's forestry problems are typical of the national situation but more acute because our industrial activities increase the demand for timber above the average and our relatively long period of habitation has depleted our timber resources below normal. The outstanding problems then are:

1. Growing a home supply of timber.
2. Profitable use of so called "waste" land and finding use for the steep and rugged areas.
3. Maintaining a forest cover for watershed protection, to help prevent floods, and for outdoor recreation.

When the timber that is now being imported into West Virginia annually is produced within her borders, as it can be, the money so spent will be kept at home. A home-grown timber supply will result in the building up of local wood-using industries, with all of their benefits to capital and labor, to the land owner and the tax payer, and to the ultimate consumer of wood—everyone. Without a home-grown timber supply assured, West Virginia will be pinched badly when the fast approaching national timber shortage becomes a reality.

In spite of the agricultural and industrial development that has been going on through the past decades we still have close to ten million acres of woodlands, which is sixty-five per cent of the entire land area of the state. In its present abused and neglected condition most of it is now non-productive. More than two-thirds of this vast area has been cut-over or so severely burned by forest fires that the present tree growth, while potentially valuable for future forests, is now too small or scattering to be usable. Much of the same area that is being tilled is so steep and rugged that it will not return sufficient income to pay for its operation. Under proper protection from fire and abuse, and with logging operations wisely regulated, this entire area can ultimately produce all the timber needed in West Virginia for years to come.

Moreover, nearly all the present wooded area is neither fit nor needed for agriculture, nor for any other use. Every year in West Virginia there are ninety-five to one hundred farms abandoned, or a total area of about 12,000 acres. This has been going on for the past twenty years so that this item coupled with the huge cut-over problem created by logging operations has brought about a situation that must be solved by the people acting as a whole. The modern trend of agriculture is toward more intensive cultivation of the better soils and better marketing conditions, rather than more farms. The problem of "Waste lands" can be solved by forestry. Unless these vast areas produce timber crops, they will continue to lie idle and non-productive, a burden on the tax-payer and a liability to the State of West Virginia.

There are other reasons for growing forests on the state's idle lands. In all parts of the state a permanent water supply is necessary as is the necessity of preventing rapid erosion of our mountain slopes. A forest cover with its overhead shade, its leaf litter of mulch and humus on the ground, aids greatly in solving both of these problems. Adequate forest cover on the

hills and ridges checks the rapid run-off which is responsible for gullying the land and holds the water, keeping the springs and wells filled and the streams running during the periods of the late summer months.

The recreational use of the woodlands is also of great importance. More than 121,000 persons took out licenses to hunt and fish in West Virginia in 1924, while other thousands used the woods for camping, touring, or hiking during their vacations. Adequate forest cover is necessary for the food, shelter and breeding of wild life and to insure the supply of fresh water in the streams, ponds, and rivers necessary for the propagation of fish. Desolate slashings, monotonous brush land, and unsightly burned areas do not serve to attract people on pleasure bent, but once the mountains of West Virginia are forested and kept free from fire they will attract the thousands that they should.

So we see that the maintenance of the forests concerns the public as a whole whether it be a vacationist or a person primarily interested in monetary values.

Private ownership has failed to provide for the renewal of forests after cutting. The timbers of commerce have continued to come largely from the original forest growth. The second growth available for use is meager and results from a let-alone policy rather than any effort on the part of woodland owners to produce a second crop to succeed the virgin growth. The wood using industries dependent on hardwoods are rapidly absorbing the limited stumpage and they will soon be compelled to shut down or go elsewhere. The consumers of hardwoods are finding good grades increasingly difficult to obtain and at correspondingly higher prices. The hardwood timber supply is limited in this country as compared with that of softwoods, and the sources of first growth material from states that now have an excess will soon cease to exist. West Virginia lies in the heart of the great Southern Appalachian hardwood belt. If we but awake to the situation a solution to the problem may be found before it is too late.

The effect of forest depletion upon communities within the timber sections of the state is also serious enough to engage the attention of the public. Small centers of population, which within the past few decades were dependent to a considerable degree upon a livelihood derived from the various phases of the lumbering industry, are no longer able to enjoy the modest prosperity which was once theirs. Since the passing of the merchantable timber

many small towns and villages have lost an important source of income, and the reaction is reflected in depopulation, vacant houses, and abandoned wood working plants. In West Virginia there are 2175 of such communities. Good examples of these are to be found in Gladwyn, Durbin, Thomas, Davis, and countless others. Nor is this the only loss to the communities or state. The depleted forest lands of no practicable utility aside from timber production, after having been stripped of all merchantable growth are permitted to become devastated by fire, thus further reducing their usefulness by destroying even their potentiality. Such lands of which there are 4,634,000 acres in West Virginia, can hope for little development by virtue of private ownership under present existing conditions and there must be a material change in economic conditions and in governmental regulations before private capital will undertake forest renewal.

Those who have been in close touch with the forestry situation in West Virginia are of the opinion that the state must adopt a policy in which positive steps are taken to maintain and perpetuate the forests now existing and to provide for reforestation where needed on non-agricultural or badly eroded lands and that this must be done in a manner that will accomplish the purpose with the least possible delay. Any program along this line that the state may adopt should embrace the greatest needs of the present time and be elastic enough to allow for modification or supplementing as future conditions would warrant.

Such a policy would need to include several basic considerations such as (1) The character of the forest land ownership; (2) the protection of forest lands from fire, insects, and diseases; (3) the adjustment of tax laws to timber crops; (4) the management of forest lands with a view to continuous growth; (5) the closer utilization and wise marketing of all material cut, and (6) progress in forest education and research.

Publicly-owned forests are undoubtedly a basic factor in a program for increased timber production. The public through state, county, and municipal government, is the agency that can best take over the cut-over and wild lands and provide the necessary protection and maintenance for the production of successive crops of timber. Nor is this a problem of the production of timber only. It is economy for the state to utilize all land to its fullest extent. Productive land adds to the wealth of a com-

munity and state by direct and indirect means. Idle and wild lands are a liability.

As to the character of forest land ownership, the nature of such ownership is important from the standpoint of stability and permanency of interest. In the United States there is at present in the hands of private interests 221 million acres of our timber lands. These are primarily held for the immediate return that they will give. Some of these corporations though are like governments they are long-lived and by example can be induced to practice forestry measures but the majority have no permanent interest in the holdings. Only about 150 million acres of our timbered area are in the hands of those who are engaged in agricultural pursuits and who would have a lasting interest in the land and timber.

Protection from fire for the wooded sections of West Virginia is being looked after in a very efficient manner by the State Game and Fish Commission whose field of endeavor along this line has been but recently made state-wide by the enactment of adequate legislation.

Another form of protection which needs attention is prevention of ravages to the living trees by insects. While this is a milder and less spectacular form of damage it is nevertheless a field demanding more than passing notice if our timbered areas are to produce profitably. What applies to the insect activities also applies to the many tree diseases.

To secure an actual practice of the measures in forestry as advocated, we must amend our tax laws in regard to our timber resources. It has truthfully been said that annual taxation of growing timber compels the same crop to pay taxes several times. The severance or yield tax is very desirable, that is taxes paid at the time of cutting with only a bare land tax paid during the period of growth. Such a law is unconstitutional in West Virginia at this time but is only one of the problems to be faced before the realization of real conservation of our timber resources is attained.

Proper management of these forest lands will do much to insure their longevity. With proper administration these lands will yield and provide (1) A cut limited to what the land can grow and still produce a sustained yield; (2) re-stocking of cut-over areas through natural reproduction; (3) additional protec-

tion of cut-over areas by slash disposal, and (4) replanting old burns and other idle forest lands.

Raising good timber is only half the game; cutting it properly and disposing of it profitably is the other half. This is a phase of forestry which must receive more attention than it has in the past for in the end it is the final disposition of the material grown which will determine whether our efforts have been rewarded.

The need for more extensive and better organized research work would be evident if the program as outlined were carried out. There is virtually a virgin field in forestry for research work and more definite knowledge of certain phases of forest production and utilization would undoubtedly lead to an earlier realization of a workable and satisfactory forest policy. This can be achieved only by an educational program conducted through the school room, press, and by actual demonstrations carried on before the eyes of the public.

Steps along these lines by the state would fill an urgent need (1) by developing backward sections of the state where the forest problems are closely allied with public welfare; (2) by growing under state control with its guaranteed permanency, at least a vast part of the timber needed to prevent a shortage; (3) by demonstrating to the private owner both the practicability and the best methods of growing, protecting, and harvesting timber crops, and (4) by making adequate provisions for public out-door recreation.

Forestry is not a fad, but a business proposition of growing, protecting, harvesting, manufacturing, and using wood and its products. Its methods are practical and the results are profitable. We must have timber and if we avoid the pinch of a real timber famine we must grow it at home. This can be done by protecting the forests from fire, by the adequate extension and development of public state forests, and by the improvement of privately-owned woodlands throughout West Virginia.

SULFUR IN COAL

THOMAS FRASER¹ and H. F. YANCEY²

The following is a brief resume of results of some recent studies of the problem of sulfur in coal. The writers have been directly engaged on only a comparatively small part of the general research program. Special acknowledgment is made for data obtained from the work of S. W. Parr, professor of Industrial and Applied Chemistry of the University of Illinois, and Dr. A. R. Powell, research chemist, The Koppers Company, Chicago, Illinois. Specific references to the work of these and other investigators who have been freely quoted appear in the text.

ECONOMIC SIGNIFICANCE OF SULFUR IN COAL

Sulfur is a deleterious ingredient found in all coals of record; regardless of rank, grade, or geographical location. Though of universal occurrence, it varies widely in amount: some of the far western American, high ash coals contain less than three-tenths of one per cent, while some of the Brazilian coals, even after preparation for market, carry as high as 12 per cent of this impurity.

The effect of an excessive percentage of sulfur is to render the coal unfit for metallurgical fuel and, in a measure, undesirable for practically all other uses. Sulfur is an active element at comparatively low temperatures and it constitutes a very undesirable impurity in any metallurgical or ceramic product. Hence, high sulfur coal is unsuited to use in any smelting, burning, or heat treating process in which the coal, or any of its combustion products, comes in direct contact with the product under treatment. Subsequent purification of the product contaminated by sulfur introduced in the fuel, is difficult, costly, and in some operations impossible. The limits generally prescribed are; for the manufacture of iron blast furnace fuel, a maximum of 1.00 per cent sulfur;³ for the manufacture of producer gas for metallurgical furnaces, 1.25 per cent; for commercial gas and by-product coal 1.00 to 1.25 per cent. For burning clay wares the allowable sulfur content depends, in a large measure, upon the grade of product being manufactured. The principal detrimental effect is the discoloration of the ware and glazes, hence the re-

¹ Assistant Professor of Mining, West Virginia University.

² Associate Chemist, U. S. Bureau of Mines. Co-author by permission of the Director.

³ Report of committee on evaluation of coal. Southern Ohio Pig Iron and Coke Association, October, 1924.

quirements for firing terra cotta ware, sanitary ware, and pottery are more exacting than for brick and sewer pipe. Parmelee⁴ gives the following as representative of general specifications: sanitary ware 1.0 per cent; terra cotta 1.0 per cent; pottery 1.5 per cent; enameled brick 1.3 per cent.

When the coal is used for steam or domestic fuel the disadvantage of high sulfur content is not so marked. Practically all the compounds of sulfur that occur in coal are combustible and their presence does not greatly decrease the unit calorific value of the fuel. High sulfur and high moisture content increase the corrosive action of flue gases in economizers and waste heat boilers. High sulfur is generally considered to be an indication of low ash softening temperature and liability to spontaneous firing in storage; but an actual causal relation of sulfur to these two phenomena is not definitely established. The fusibility of coal ash depends primarily upon the ratio of silica and alumina to the bases present. Since a coal which is high in pyritic sulfur is necessarily high in iron, the percentage of iron oxides in the ash is likely to be such as to form with the silica a slag which will fuse at comparatively low temperatures, although this is not invariably true.⁵ Sulfur in organic combination with the coal does not enter into the ash.

In the European countries, where the reserves of good coal are much smaller than in America, the sulfur problem is already acute, necessitating pre-treatment of much of the coal used for coking. In the United States there are extensive deposits, mainly in the Appalachian region, of high grade, low sulfur coking coals; but, even here, such coals are exceptional and constitute only a very small part of the total resources of high grade coal. In the Appalachian and eastern interior provinces including West Virginia, there are very extensive areas underlain by coal suitable, in every respect except sulfur content, for metallurgical use. Such coals are now being used to some extent in those industries nominally requiring low sulfur coal and, in the future, these industries must draw an increasing proportion of their fuel from this source. This being the case, an understanding of the physical and chemical nature of the sulfur compounds in coal and their behaviour in the coal preparation and coal utilization processes is essential.

⁴ Effect on sulfur in coal used in the ceramic industries. Trans. Am. Inst. Min. Eng. Sept., 1919.

⁵ Fusibility of ash from coals of the United States; W. A. Selvig and A. C. Fieldner, U. S. B. M. Bull. 209.

FORMS OF SULFUR IN COAL

The conspicuous sulfur compound in coal is iron pyrite or marcasite. Calvert¹ was the first to recognize the existence of sulfate sulfur in coal and propose a method for its quantitative determination. Numerous analyses have shown this form of sulfur to be insignificant in amount in freshly mined coal except in a few far western deposits which contain unusual amounts of gypsum. Coal samples that have been exposed for some time may contain appreciable amounts of sulfate sulfur due to the oxidation of the sulfides. In 1872 Emery², working on Iowa coals, found some samples to contain sulfur in excess of the amount required to form iron disulfide with all the iron present. This indicated the presence of sulfur in organic combination with the coal. Powell and Parr³ have proved, by isolation in ashless, organic constituents of the coal, the presence of organic sulfur; and have developed a method for separate quantitative determination of sulfate sulfur, pyritic sulfur, and two distinct forms of organic sulfur.

Sulfate sulfur is extracted by dilute hydrochloric acid; pyritic sulfur⁴ is determined by the amount required to combine with the pyritic iron in the dilute nitric acid extract; organic sulfur is determined by difference or directly by analysis of the ashless, phenol-soluble fraction of the coal—which gives the phenol-soluble organic sulfur—and of the ammonia soluble portion of the residue remaining after phenol extraction and digestion in concentrated nitric acid—which gives the humous organic sulfur. The exact chemical relation of this sulfur to the organic matter of the coal is not known.

In freshly mined coal the sulfate mineral is gypsum which generally occurs as very thin white flakes in vertical joint fissures. Physically, the pyrite occurrences vary widely. Typical formations are; thin bands interbedded with the coal; lenticular masses with larger dimensions parallel to the bedding planes; thin plates and films in joint fissures; and rounded nodules varying from a foot or more in diameter to microscopic size. Thiessen⁵ has examined, in thin section, a great number of American coals and found all that he has studied to contain microscopic particles

¹Chemical News. Vol. 24, p. 76 (1871).

²Am. Jour. Sci. Arts. Vol. 3, p. 34 (1872).

³University of Ill., Eng. Exp. Sta. Bull., 111, 1919.

⁴Powell, A. R. The Analyses of Sulfur Forms in Coal, U. S. B. M. tech. paper, 254.

⁵Trans. Am. Inst. Min. Engrs. Vol. 63, p. 913.

of pyrite or marcasite. Similar microscopic sulfur particles in English coal are reported by Lomax¹¹ and in Japanese coals by Iwasaki¹².

FORMS OF SULFUR IN VARIOUS COALS

Precise methods for the determination, separately, of the different forms of sulfur in coal have not been available long enough for much analytical data to be accumulated. Samples of a few important coal beds have been examined during the Bureau of Mines coal preparation investigations and the results, with several gleaned from other sources, are presented in Table 1.

TABLE 1.—COAL FROM DIFFERENT SOURCES
SHOWING SULFUR CONTENT

Location of Mine	Coal Bed	Total Sulfur	Pyritic Sulfur	Organic Sulfur	Organic Sulfur as Per cent of Total Sulfur
Clearfield Co., Pa.....	C. & D.....	3.56	2.82	0.74	20.8
Franklin Co., Ill.....	No. 6.....	2.52	1.50	1.02	40.5
Franklin Co., Ill.....	No. 6.....	1.50	0.81	0.69	46.0
Union Co., Ky.....	No. 9.....	3.28	1.05	2.23	68.0
Union Co., Ky.....	No. 9.....	3.46	1.65	1.81	52.5
Webster Co., Ky.....	No. 12.....	1.48	0.70	0.78	52.6
Pike Co., Ky.....	Freeburn.....	0.46	0.13	0.33	72.0
McDowell Co., W. Va.....	Pocahontas 3	0.55	0.08	0.46	83.7
Letcher Co., Ky. ¹³	Elkhorn.....	0.68	0.13	0.51	75.0
Boone Co., W. Va.....	Eagle.....	2.48	1.47	1.01	4.05
Walker Co., Ala.....	Pratt.....	1.62	0.81	0.81	50.0
Jefferson Co., Ala.....	Pratt.....	1.72	0.97	0.72	41.9
Jefferson Co., Ala.....	Mary Lee...	1.05	0.33	0.69	65.7
Clay Co., Ind.....	No. 3.....	3.92	2.13	1.79	45.7
Cummock, N. C.....	Deep River..	2.32	1.52	0.80	34.5
Cummock, N. C.....	Deep River..	2.08	1.53	0.55	26.4
Natal, So. Africa.....	.....	1.51	0.47	0.97	64.2
Transvaal, So. Africa.....	.....	1.39	0.59	0.70	50.4
Transvaal, So. Africa.....	.....	0.44	0.06	0.37	84.1
Brazil, S. A.....	.....	2.39	1.78	0.50	20.9
Intria, Italy ¹⁴.....	.....	9.01	1.09	7.90	87.7
Germany, bituminous.....	.....	1.78	0.92	0.76	42.7
Germany, brown ¹⁵.....	.....	3.15	0.02	3.06	97.1
Germany, brown ¹⁶.....	.....	4.77	0.15	4.57	95.8
Bohemia, brown ¹⁷.....	.....	0.76	0.27	0.46	60.5

Sulfate sulfur values are not recorded in the table. Where the sum of pyritic and organic sulfur is not equal to total sulfur, the difference is sulfate sulfur.

¹¹ Trans. Inst. Min. Engrs. Vol. 46, p. 592.

¹² Colliery Guardian. Vol. 120, p. 797.

¹³ Powell, Ind. and Eng. Chem., 12, 889 (1920).

¹⁴ Donath and Indra, Chem. Ztg., 36, 1119 (1912).

¹⁵ Foerster and Geisler, Z. Angew. Chem., 35, 193 (1922).

While these data are meager, they are sufficient to show that sulfur in organic combination with the coal may make up a large part of the total sulfur present and it is therefore a factor of importance in the beneficiation and utilization of the coal.

BEHAVIOR OF SULFUR IN COAL TREATMENT

Having established the existence of these various forms of sulfur in coal, it is of importance to know how they behave in the various processes by which coal is cleaned and used. This is especially important in those industries that require low sulfur fuel. In the manufacture of steel, for example, proven methods have been proposed by which excessive sulfur may be removed in any step in the process—in the coal treatment plant; the coke oven; the blast furnace; or the open hearth. It is easily conceivable that the original form in which the sulfur is present in coal may have a bearing on the effectiveness of these sulfur removing processes. It is possible to make good pig iron with high sulfur coke but the operation is difficult and expensive. For the most economical production, purification of the materials should take place at as early a stage as possible.

Practically all the coal treatment processes for removal of sulfur depend upon difference in specific gravity between coal and impurity particles. The froth flotation process and the Trent process operate on a different principle, but all are strictly mechanical processes requiring that the coal and impurities be broken apart into separate pieces. Hence it is obvious that organic sulfur is non-removable. The microscopic particles of pyritic sulfur are equally irremovable in practice; and the finer a-microscopic particles require such fine pulverization of the coal to free them that their removal is also impracticable. Furthermore, since the processes of gravity concentration are not 100 per cent effective, the pyrite that is broken free from the coal is not completely removable. The difficulty of separation increases with the fineness of the particles. Therefore, the only removable form of sulfur in coal is pyrite (or marcasite) in particles of such size that they can be broken free from the coal without crushing to prohibitively fine size. If gypsum occurs in appreciable amount it is partially removable, but it is usually negligible.

Table 2 gives the sulfur reductions obtained in cleaning tests on a number of coals containing varying proportions of pyritic and organic sulfur.

TABLE 2.—SULFUR REDUCTION BY WASHING. VALUES IN PER CENT. MOISTURE FREE BASIS.

Coal Bed Tested	Sulfur in Raw Coal Per Cent			
	Total	Pyritic	Finely Disseminated Pyritic	Organic
Eagle Seam, Ramage, W. Va....	2.48	1.47	.71	1.01
C. & D. Clearfield Co., Pa.....	3.48	2.77	.50	.71
Bon Air, Tenn.....	4.83	3.70	1.83	1.12
No. 6, Seam, Illinois.....	2.05	1.22	.47	0.83

WASHING RESULTS

Coal	Washer Used	Washed Coal			
		Yield	Sulfur Content	Sulfur Reduction	
				Total	Pyritic
Eagle.....	Table.....	87	1.95	21.4	36
Clearfield.....	Table.....	74.7	1.53	56	68
Bon Air.....	Jig.....	86.9	3.80	21.4	38
Illinois, No. 6.....	Air Table.....	94.1	1.53	25.4	45.2

The variations in pyritic sulfur reduction are due to differences in physical form of the pyrite in the different coals.

A study¹²⁵ of the occurrence and distribution of the various forms of sulfur in several coal beds in Illinois, Kentucky, and Alabama has shown that the fluctuations in sulfur content in coal from a given mine are mainly due to the variation in pyritic sulfur. That is, the excess of sulfur in exceptionally dirty samples is largely in the form of pyrite and usually in particles of removable size. A cleaning operation, therefore, tends to base-level the product, reducing the sulfur content to a percentage somewhere above the normal organic plus fine disseminated pyritic sulfur content, these two non-removable forms being much more uniform than the coarse removable pyrite. This residual non-removable sulfur is often called the inherent sulfur. The same sort of condition generally exists in regard to the ash forming impurities.¹²⁶ The peaks consist mainly of coarse removable slate or shale.

¹²⁵ Distribution of the Forms of Sulfur in the coal bed, Ill. Eng. Exp. Sta. Bull. 125. Sulfur forms in coal, their distribution and control. Yancey, H. F. & Parr S. W. Jour. Ind. and Eng. Chem., Vol. 16, No. 50, p. 501

¹²⁶ Interpretation of results of coal washing tests. Fraser, T. Yancey, H. F. Trans. Am. Inst. Min. Engrs., 69, 447.

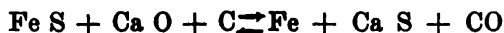
BEHAVIOR OF SULFUR IN COKING OPERATION

During the coking operation, a part of the coal sulfur is driven off with the gas. The proportion so expelled varies in different coals. By making coking tests on different specific gravity fractions of coal samples so as to get different proportions of organic and pyritic sulfur, McCullum²⁸ concluded that a greater proportion of the organic sulfur was expelled than of the pyritic; but he obtained no very conclusive results. Campbell²⁹ considered practically all the sulfur to be pyritic and that this is converted to pyrrhotite (of the composition Fe_7S_8) in the coking operation—this resulting in volatilization of 42 per cent of the sulfur.

Powell³⁰ in a recent extensive investigation of the behavior of the different forms of coal sulfur during coking, found that the pyrite is completely decomposed to ferrous sulfide, pyrrhotite, and hydrogen sulfide at 300° to 600° C. temperature range. One-fourth to one-third of the organic sulfur is broken up and driven off as hydrogen sulfide in the primary reactions and this proportion is increased to as much as one-half by the action of free hydrogen in the by-product gases passing through the coking mass. The remainder of the organic sulfur he considers to be retained by the carbon in solid solution except that small quantities enter into volatile organic compounds that find their way into the tar. When the coke is quenched a part of the ferrous sulfide is oxidized producing mainly free sulfur which is adsorbed by the coke. Thus Powell names the sulfur forms in commercial coke as (1) solution of sulfur in coke, (2) ferrous sulfide, (3) adsorbed free sulfur, and (4) sulfates.

BEHAVIOR OF COKE SULFUR IN THE BLAST FURNACE

Sulfur is carried into the iron smelting operation mainly by the coke, although all the raw materials will contain some sulfur. It leaves the furnace distributed between the iron and the slag, being present in the iron as ferrous sulfide or manganese sulfide and in the slag as calcium sulfide. Very little goes off in the gases. The conditions that control the distribution of sulfur between iron and slag are quite well known and the reaction is generally expressed as follows:



²⁸ Chem. Eng. VII, p. 27.

²⁹ Am. Inst. Min. Engrs. 1916, p. 177.

³⁰ Jour. Ind. and Eng. Chem. V. 12, 1920, p. 1069.

Slag and iron compete for the sulfur in the combustion and slagging zones of the furnace, the iron probably taking sulfur from the coke in the earlier stages of the operation and being desulfurized by the slag in the final stages. The Bureau of Mines has made a study of the transfer of sulfur from coke to iron and slag in the furnace. Powell²² in presenting the results of these investigations outlines the behavior of the sulfur compounds as follows:

1. In the reduction zone of the furnace, free sulfates of the coke are reduced to ferrous sulfide.

2. In the iron-sponge zone, the ferrous sulfide of the coke is broken up, the sulfur being volatilized and taken up by the lime as calcium sulfide and by the iron as ferrous sulfide in solid solution in iron.

3. In the zone of slag formation, the stone fuses and forms, with the silicious constituents of the ore, a viscous basic slag which coats the coke and iron and, since it has a great affinity for sulfur, probably stops the transfer of sulfur from coke to iron.

4. In the combustion zone the coke is entirely consumed and the combined sulfur liberated to enter into the iron as ferrous sulfide or the slag as calcium sulfide, the distribution depending in a large measure upon the relative intimacy of contact of the slag and the iron with the coke. It is the general conception that, up to this stage of the operation, the iron is taking up sulfur from the coke and that desulfurization then takes place mainly in the hearth where the temperatures are relatively high, both iron and slag are highly fluid, and the globules of iron pass down through the slag into the bottom of the hearth. Experiments of McCaffery²³ and Oesterle establish this condition. Final distribution of the sulfur here depends upon the relative solubilities of the iron for ferrous sulfide and the slag for calcium and magnesium sulfides.

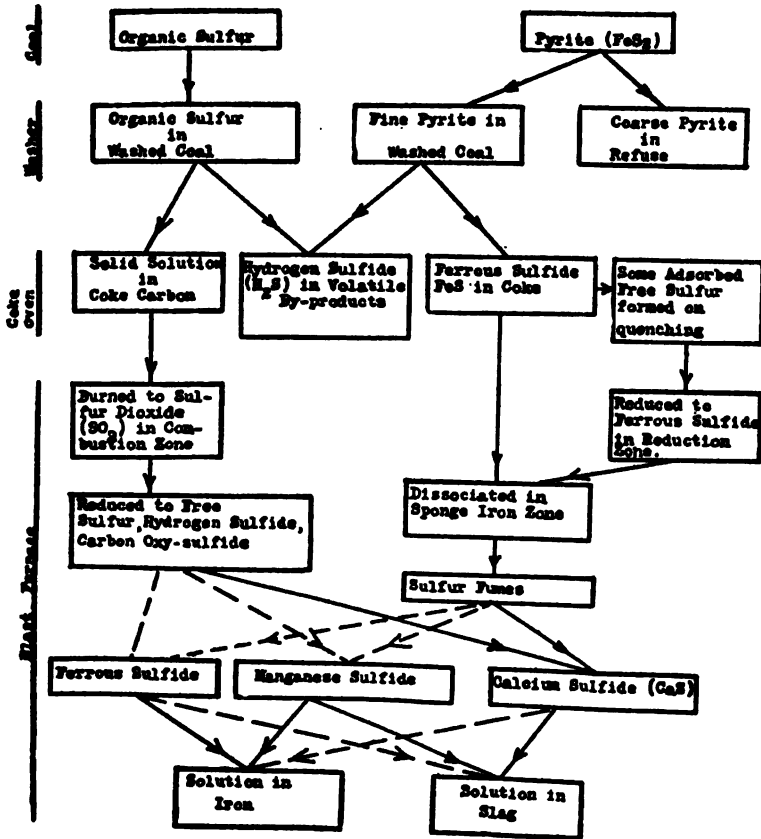
SUMMARY

The accompanying diagram shows the various routes by which the sulfur forms present in raw coal are finally disposed of in the production of pig iron. Although this diagram is far from complete it shows the principal changes which the coal sulfur compounds undergo.

²² Trans. Am. Inst. Min. engrs. V. 69, p. 587.

²³ Trans. Am. Inst. Min. Engrs. V. 69, p. 606.

COAL-COKE-IRON-SLAG SULFUR-TRANSFER DIAGRAM



THE HYDROLYSIS OF ESTERS IN ALKALINE SOLUTION

By GEO. R. BANCROFT

The first investigator to study velocity of hydrolysis of esters in alkaline solution seems to have been Warder¹, who published the results of his research in 1881. This work was undertaken by Warder, following some studies made by him in alkalimetry upon the use of phenolphthalein² as an indicator, the results of which were very satisfactory. His attention had been directed to this problem by the fact that much work had been done on the subject of esterification, and he saw in the phenolphthalein a sensitive indicator for the presence of weak acids, which would enable him to investigate the rate of decomposition in an ester like ethyl acetate.

Warder made measurements on the rate of hydrolysis of ethyl acetate at 20.5° and 21°C. from which he was able to obtain good constants, calculated according to the mass law for second order reactions. Measurements were also made at several temperatures, ranging from 36° to 37.7°C., and an empirical relation was established from the velocity-temperature curve which approximated to an equilateral hyperbola. The formula derived was $(7.5+a)(62.5-t)=521.4$ in which a is the velocity and t is the temperature. In doing this work he used equivalent quantities of alkali and ester, and followed the course of the reaction by titrating the excess of alkali in 100 cc. portions of the reaction-mixture with eighth-normal oxalic acid. His experiments showed the great velocity of this type of hydrolysis, and proved that measurements can only be made in very dilute solutions.

From 1885-1887, there appeared in Liebig's *Annalen der Chemie* three articles by Reicher³, who had carried on investigations along the same line as that begun by Warder. His first paper describes in detail his methods of experimental procedure and calculation of constants. He decomposed the esters with standard alkali in a specially constructed apparatus, which permitted of very exact adjustment of the temperature. After successive intervals of time, a definite portion of the reaction-mixture

¹ Warder, *Ber. Dtsch. Chem. Gesellsch.*, 1881, 14, 1361; *Amer. Chem. Journal*, 1881, 3, 340.

² Baeyer, *Ber. Dtsch. Chem. Gesellsch.*, 1874, 4, 658; *Luck. Zeitsch. Anal. Chem.*, 1877, 16, 332; Warder, *Amer. Chem. Journal*, 1881, 3, 55.

³ Reicher, *Lieb. Ann. d. Chemie*, 1885, 228, 257; 1886, 232, 103; *Lieb. Ann. d. Chemie*, 1887, 238, 276.

was poured into an excess of standard sulphuric acid, and the excess of acid was determined by titration with standard barium hydroxide. The mixing of solutions was accomplished by means of a mercury displacement apparatus, and every detail of his experimental procedure was carried out with the greatest exactness. The only possible source of error seems to have been the doubtful purity of the samples of some of the esters used. This was guarded against however, by the performing of some preliminary experiments, which proved that no errors occurred when the esters were associated with considerable quantities of alcohol or free organic acid. The results obtained by Reicher can be best presented for our purpose by summarizing them as was done in the original articles.

In the summary of the first article⁴, attention is called to results of experiments performed to determine the influence (1) of different bases, (2) of the alcohol radicle (3) of the acyl radicle upon the velocity of saponification.

To determine the influence of different bases on the rate of saponification, experiments were performed at a temperature of 9.4°C. on ethyl acetate in solutions of various bases. The following constants were obtained:

Temperature: 9.4°C.	Constants.
NaOH	2.307
KOH	2.298
Ca(OH) ₂	2.285
Sr(OH) ₂	2.204
Ba(OH) ₂	2.144
NH ₄ OH	0.011

The last value is only approximately accurate, as it is the average of but two constants. A slight decrease is observed in the constants as the molecular weight of the base increases.

To discover the influence of the alcohol radicle on the reaction velocity, the acetates of several alcohols were hydrolyzed in sodium hydroxide solution.

Temperature: 9.4°C.	Constants.
Methyl acetate	3.493
Ethyl acetate	2.307
Propyl acetate	1.920
Iso-butyl acetate	1.618
Iso-amyl acetate	1.645

⁴ Reicher, Lieb. Ann. d. Chem., 1885, 228, 257.

There is a decrease in velocity as the molecular weight increases in all cases but one. This decrease becomes less marked as the size of the alcohol radicle increases.

To investigate the effect of the acyl radicle upon the rate of cleavage, experiments were conducted upon the ethyl esters of various acids in sodium hydroxide solution.

Temperature: 14.4°C.	Constants.
Ethyl acetate	3.204
Ethyl propionate	2.816
Ethyl butyrate	1.702
Ethyl iso-butyrate	1.731
Ethyl iso-valerate	0.614
Ethyl benzoate	0.830

Here again a falling off in velocity occurs with increase of molecular weight. Ethyl benzoate is an exception on account of its different structure.

In the second article¹, Reicher gives further results obtained from measurements made to show the effect of different bases on the rate of saponification. These results are summarized in the following table:

Ester	Temperature	K for NaOH	K ₁ for Ba(OH) ₂	K ₁ /K
Methyl acetate	9.4	3.493	3.516	1.007
Iso-amyl acetate	9.4	1.645	1.660	1.009
Ethyl acetate	9.4	2.307	2.144	0.929
Ethyl iso-valerate	14.4	0.614	0.597	0.972

This work led the author to a conclusion contrary to that given in his first paper², namely, that the nature of the base has little to do with the rate of saponification.

In the last part of this paper, Reicher shows the inadequacy of Warder's temperature formula³; $7.5 + a(62.5 - t) = 521.4$, since at 62.5°C. the velocity co-efficient a becomes infinite.

On the basis of thermodynamics, another relation may be obtained which in its integrated form is:

$$\log K = -\frac{T}{A} + BT + C$$

where K is the velocity constant, T, the absolute temperature, and A, B, and C, are constants, characteristic of the reaction. To determine the latter, values of K at three different temperatures must be known.

¹ Reicher, Lieb. Ann. d. Chem., 1886, 232, 108.

² Reicher, Lieb. Ann. d. Chem., 1885, 228, 257.

³ Warder, Amer. Chem. Journal, 1881, 3, 347; Ber. Dtsch. Chem. Gesellsch., 1881, 14, 1361.

For ethyl acetate, the formula becomes:

$$\log K = 4.53 - .00754 T - \frac{1780}{T}$$

Results calculated according to this formula agreed with experimental values at various temperatures ranging from 9.4° to 44.9°C.

All the experiments discussed in the first two papers, were conducted with the alkali in excess of the ester. By the mass law, the same constants should be obtained with the ester in excess, and measurements were made to determine this point. The third paper³ in this series gives an account of the results of this work. The first series indicated a disagreement, which was afterwards shown to be due to experimental error. Upon more carefully regulating conditions Reicher was able to show in a second series that the rate of saponification remains the same and is independent of whether the ethyl acetate or sodium hydroxide is in excess.

In 1887, Ostwald⁴ published a paper in which he compared the relative velocities of saponification produced by various bases upon ethyl acetate with their strength as determined by electrical conductivity measurements. The concordance of the results obtained was quite satisfactory, except in the case of the weaker bases, as ammonium hydroxide and some of the amines. The irregularities in these cases were made evident by the progressive falling off in each series of constants, and were attributed to the influence of the products formed upon the reaction.

In the same year, and following upon the work of Ostwald, Arrhenius⁵ conducted a series of experiments to determine the effect of neutral salts on velocity of saponification. He found that with the strong bases the changes were very slight, when the concentration of the added salt was approximately equal to that of either of the reacting substances. Most salts when associated with the stronger bases, were found to produce a retardation of the rate of hydrolysis; but some produced an acceleration, as was found in the case of the sulphates and thiosulphate. With ammonia the effect was found to be over two thousand times as great as with the strong bases and this, in part at least, accounted for the irregularities noticed by Ostwald. A three constant formula was worked out by Arrhenius, which applied to cases of saponi-

³ Reicher, Lieb. Ann. d. Chem., 1887, 238, 276.

⁴ Ostwald, J. pr. Chem., 1887, (2), 85, 112.

⁵ Arrhenius, Zeitschr. phys. Chem., 1887, 1, 110.

fication by ammonium hydroxide, and which took into account the variations caused by the presence of a neutral salt.

In the following year, there appeared a paper by Spohr¹¹ dealing with the influence of neutral salts upon a large number of chemical reactions. A portion of this paper dealt with their effect upon the saponification of ethyl acetate by potassium hydroxide. The results given in this part of his work were similar to those obtained by Arrhenius.

In 1897, Sudborough and Feilmann¹² announced that the substitution of halogen had the effect of greatly increasing the rate of alkaline hydrolysis. It was also proposed by Sudborough at this time that the velocity of saponification was controlled by two factors, strength of derived acid and steric influence. The work of Hjelt¹³ on the saponification of esters of dibasic acids gave support to this theory.

In 1899 and 1900, two papers were published by Goldschmidt and Oslan¹⁴ on the hydrolysis of ethyl acetoacetate with sodium hydroxide. In the first of these papers, it was shown that this saponification is a reaction of the first order, although, at first it might appear to be similar to the others that have been considered, and in which the second order formula has been found to apply. This fact has been explained in the following way¹⁵: When equivalent portions of sodium hydroxide and ethyl acetoacetate are placed together in solution, a reaction immediately takes place which results in the formation of the sodium salt of the ester. This salt is to a certain degree hydrolyzed, and the main reaction takes place between the products of this hydrolysis, which are free ester and base. The concentration of either of these is proportional to the square root of the concentration of the undecomposed salt, which, when the degree of saponification is small, is practically equal to that of either of the original constituents. This means that the rate of reaction is equal to the product of the two constants multiplied by the product of the square roots of the concentrations of the original ester and base. The differential equation derived from this relation is equivalent to that representing a first order reaction.

¹¹ Spohr, *Zeitschr. phys. Chem.*, 1888, 2, 184.

¹² Sudborough and Feilmann, *J. Chem. Soc.* 1897, 73, 241.

¹³ Hjelt, *Ber. Dtsch. Chem. Gesellsch.*, 1896, 29, 110; 1898, 31, 1844.

¹⁴ Goldschmidt and Oslan, *Ber. Dtsch. Chem. Gesellsch.*, 1899, 32, 3390; *Ber. Dtsch. Chem. Gesellsch.*, 1900, 33, 1140; *J. Chem. Soc.*, 1900, 78, 182 and 873.

¹⁵ E. W. Dean, *Dissertation*, 1924.

In 1905, a paper was published by Findlay and Turner¹⁸ dealing with the influence of hydroxyl and alkoxy groups in the acyl radicle upon the velocity of saponification. The experiments conducted by these men form the most important investigation in connection with this work performed since the time of Reicher¹⁹. The work of the latter, while quite comprehensive, did not deal with the substitution of alkyl groups in the acyl radicle. The results given in this paper were obtained at a temperature of 25°C. by the titration method, and calculated by means of the titration formula. Knowing of the ease with which ethyl lactate is saponified in comparison with ethyl propionate, and of the work of Goldschmidt²⁰ on the enolic form of ethyl acetoacetate the belief was held that substituted acetates and propionates reacted too rapidly to be measured. For this reason, these investigators selected phenyl acetates and esters of mandelic acid for the purpose of their study.

Four years later, a second paper appeared by Findlay and Hickmans²¹, in which the list of esters studied was considerably extended by a continuation of investigations along this line. In this second paper, the conductivity method of Walker²² was employed in making the measurements from which the velocity constants were calculated.

The results obtained in these two researches can most readily be shown by giving some of their tables of constants.

I. THE EFFECT OF THE ALCOHOL RADICLE

Temperature 25°C. with NaOH. Constants.		Constants.
Methyl acetate	9.66	Methyl mandelate 157
Ethyl acetate	6.94	Ethyl mandelate 66
Propyl acetate	5.31	Propyl mandelate 55

In this table the values of the saponification of methyl and propyl acetates have been calculated from the figures obtained by Reicher¹⁹, while that for ethyl acetate was determined by Schmidt²³. A qualitative similarity in the effect of the alcohol radicle may be seen in the two series, but the mathematical ratios are very different.

¹⁸ Findlay and Turner, J. Chem. Soc. 1905, 87, 747.

¹⁹ Reicher, Lieb. Ann. d. Chem., 1885, 228, 257.

²⁰ Goldschmidt and Osan, Ber. Dtsch. Chem. Gesellsch., 1899, 32, 3390.

²¹ Findlay and Hickmans, J. Chem. Soc., 1909, 95, 1004.

²² Walker, Proc. Roy. Soc., Series A, 1908, 78, 157.

²³ Reicher, Ann. d. Chem. 1885, 228, 257.

²⁴ Schmidt, Ber. Dtsch. Chem. Gesellsch., 1899, 32, 3396.

II. THE EFFECT OF THE ACID RADICLE

A. *Relative effect of the groups of OH and OR*

Temperature 25°C. with NaOH.	Constants.
Ethyl phenyl acetate	12.4
Ethyl mandelate	66.0
Ethyl methoxy-phenyl acetate.....	23.3
Ethyl ethoxy-phenyl acetate.....	15.7
Ethyl propoxy-phenyl acetate	13.3

It is to be noted that these substitutions produce an increase in the rate of saponification in every case.

B. *Influence of the phenyl group*

Esters	Ratio of Constants. K_1/K_2
Ethyl phenyl acetate: methyl acetate.....	2.3
Ethyl phenyl acetate: ethyl acetate.....	1.9
Ethyl phenyl propionate: ethyl propionate.....	1.3
Ethyl mandelate: ethyl glycollate.....	0.88
Ethyl alpha-hydroxy-phenyl propionate: ethyl lactate	0.63

From this table it is seen that the introduction of a phenyl group into propionic or acetic acid raises the value of the velocity constant of the ethyl and methyl esters. On the other hand, introduction of the phenyl group into glycollic or lactic acid, both of which contain the hydroxyl group, lower the value of the constants. The influence of the phenyl group is also seen to diminish with increase in the molecular weight of the ester.

C. *Influence of the alpha-hydroxyl group*

Esters	Ratio of Constants. K_1/K_2
Ethyl glycollate: ethyl acetate.....	11.5
Ethyl lactate: ethyl propionate.....	11.95
Methyl mandelate: methyl phenyl acetate.....	5.7
Ethyl Mandelate: ethyl phenyl acetate.....	5.3
Ethyl alpha-hydroxy-phenyl propionate: ethyl phenyl propionate	5.8

In this case, we find a very marked antagonistic action between the phenyl and hydroxyl groups introduced into the same molecule. The hydroxyl group in all cases exercises an accelerating influence on the velocity of saponification. Hydroxy-substituted esters react with velocities five to twelve times those of the corresponding unsubstituted products.

D. Effect of alpha- and beta- positions

Temperature 25°C.

Constants

Ethyl phenyl propionate..... 5.3

Ethyl alpha-hydroxy phenyl propionate.....40.1

Ethyl beta-hydroxy phenyl propionate..... 4.1

Here we find that the beta-hydroxyl produces a slight retardation of the velocity while the alpha-hydroxyl produces a considerable acceleration.

E. Relation of velocity constant and strength of acid

It appears also from this paper, and from the work of Reicher²², Hjelt²³, Sudborough²⁴, and others that the strength of the derived acid is an important factor in determining the rate of saponification. However, it is not a measure of the velocity and is not always a qualitative indication of its relative value.

In 1913, Dean²⁵ performed some experiments for the purpose of studying the saponification of hydroxy- and alkoxy-acetates and propionates with sodium hydroxide. Hydrolysis measurements were made on twelve esters of the class just named, and constants were calculated. The experiments were carried on by a slight modification of the method recommended by Ostwald²⁶, and the calculations were made by the use of the titration formula²⁷ for reactions of the second order.

$$K = \frac{1}{.4343 \cdot t \cdot T_{\infty}} \cdot \frac{V}{n} \left[\log T - \log (T_0 - T_{\infty}) - \log T_0 - \log (T - T_{\infty}) \right]$$

in which n = normality of the hydrochloric acid used, t = time elapsed between first titration and any one in the series.

T_0 , T , and T_{∞} represent respectively quantities of the hydrochloric acid solution used up by the excess of alkali at the beginning, at the end, and at any time, t ; V = volume of pipette used to withdraw portions of the reaction-mixture for titration.

²² Reicher, Ann. d. Chem., 1885, 228, 257.

²³ Hjelt, Ber. Dtsch. Chem. Gesellsch., 1896, 29, 110; 1898, 31, 1844.

²⁴ Sudborough and Fellmann, J. Chem. Soc., 1897, 73, 241.

²⁵ Dean, Amer. J. of Science, 1913, (4) 35, 606.

²⁶ Ostwald, Luther; Physike, Chemische Messungen, 3rd edition, p. 529.

²⁷ Findlay, Practical Physical Chemistry, p. 243.

Measurements were also made by the electrical conductivity of Walker²², which had been employed by Findlay and Hickmans²³, and results were obtained which were in accord with those found by the titration method, and the method is recommended by Dean²⁴ as a simpler laboratory procedure.

The conclusions resulting from these investigations are here given as summarized by Dean.

A. The effect of the alcohol radicle.

Velocity of saponification falls off with increase in the size of the alcohol radicle, and the difference between any two members becomes less, the higher one goes in the series. Thus the variation between methyl and ethyl acetates is greater than between ethyl and propyl esters. This seems to be a general rule.

B. The effect of alkyl substitution in the acyl group.

The general effect of the substitution of alkyl groups is to decrease the velocity of saponification.

C. The effect of hydroxyl groups.

Nearly all hydroxy-esters saponify more rapidly than those of the corresponding unsubstituted acids.

D. The effect of alkoxy groups.

The presence of alkoxy groups may result in anything from a slight retardation to a tremendous acceleration of the rate of saponification. Acceleration is by far the more common effect. Esters of any series show a falling off of velocity with increase in the size of the alkoxy group.

E. Effect of alpha- and beta- substitution.

All alpha-substituted esters saponify more rapidly than the corresponding beta- compounds.

F. Relative velocities of saponification of esters of normal and iso-acids.

The results of a very limited number of measurements indicate that the esters of normal acids saponify more rapidly than those of the corresponding iso-acids.

G. Effect of halogens and the cyanogen group.

Qualitative results indicate a tremendous acceleration produced by the substitution of halogens or cyanogen in the acyl radicle.

H. The relation of the rate of saponification to the strength of derived acid.

There seems to be no doubt that the rate of saponification is largely controlled by the strength of the derived acid, but is by no means entirely controlled by this factor.

²² Walker, Proc. Roy. Soc., 1908, Series A, 78, 155.

²³ Findlay and Hickmans, J. Chem. Soc., 1909, 95, 1004.

²⁴ E. W. Dean, Dissertation, 1914.

BULLETIN OF THE WEST VIRGINIA UNIVERSITY SCIENTIFIC ASSOCIATION

VOL. III
NO. 1



AUGUST
1926

CONTENTS

	Page
List of officers of the West Virginia University Scientific Association	2
Programs of the Association	3
Conservation of Bituminous Coal and Accompanying Carbonaceous Matter	5
Predicable Value of Intelligence Tests	10
The Natural Methyl Anthraquinone Derivatives	14
A Theory of Wireless Propagation	21
Some Theorems on the Zeroes of Solutions of Self-adjoint Homogeneous Linear Differential Equations of the Fifth Order....	26
The University Heating Plant	33
George R. Lyman	38
Samuel B. Brown	40

**OFFICERS
OF THE
WEST VIRGINIA UNIVERSITY
SCIENTIFIC ASSOCIATION**

PAST PRESIDENTS

A. R. Whitehill	1914-15
S. B. Brown	1915-16
F. E. Emory	1916-17
C. W. Waggoner	1917-18
B. H. Hite	1918-19
A. M. Reese	1919-20
Aaron Arkin	1920-21
N. J. Giddings	1921-22
R. P. Davis	1922-23
G. S. Dodds	1923-24
George R. Bancroft	1924-25
G. H. Gill	1925-26

OFFICERS FOR 1926-27

President	W. W. Hodges
Vice-President	Earl R. Scheffel
Secretary	R. J. Garber
Treasurer	F. A. Molby

PROGRAMME COMMITTEE

F. E. Chidester
J. E. Winters
E. P. Deatrick

PUBLICATION COMMITTEE

H. G. Knight, **Chairman**
W. W. Hodge
E. R. Scheffel
J. E. Winter
E. P. Deatrick
P. D. Strausbaugh

*West Virginia Univ.
Spec.
4-24-1928*

THE WEST VIRGINIA UNIVERSITY SCIENTIFIC
SOCIETY HELD THE FOLLOWING MEETINGS
DURING THE YEAR 1925-1926

October 19, 1925.

Speaker: Dr. H. W. Streeter.
Subject: "Water Purification."

December 4, 1925.

Speaker: Dr. P. D. Strausbaugh.
Subject: "Vegetation of the Dune Areas Around the
Lower End of Lake Michigan."

January 29, 1926.

Speaker: Dr. H. G. Knight.
Subject: "Cooperative Research."

February 26, 1926.

Speaker: Dr. H. E. Cunningham.
Subject: "Some Fundamental Concepts of the Physical
Sciences."

March 26, 1926.

Speaker: Dr. R. C. Colwell.
Subject: "The Constitution of Matter."

April 29, 1926.

Speaker: Dr. John Merle Coulter.
Subject: "Original Exploration of Yellowstone Park."

May 28, 1926.

Speaker: "Dr. T. W. Grayson.
Subject: "Some Modern Dietary Tendencies."

R. J. GARBER, Secretary.

WEST VIRGINIA UNIVERSITY

MORGANTOWN

Established February 7, 1867

THE STATE BOARD OF CONTROL

TERM EXPIRES

JAMES S. LAKIN, PRESIDENT, Charleston June 30, 1927
C. A. JACKSON, Charleston June 30, 1929
F. W. McCULLOUGH, TREASURER, Charleston June 30, 1931

The State Board of Control has the direction of the financial and business affairs of the state educational institutions.

THE STATE BOARD OF EDUCATION

TERM EXPIRES

GEORGE M. FORD, STATE SUPERINTENDENT OF SCHOOLS,
PRESIDENT, Charleston March 4, 1929
W. G. CONLEY, Charleston June 30, 1932
MRS. LENA LOWE YOST, Charleston June 30, 1927
BERNARD McCLAUGHERTY, Bluefield June 30, 1928
***EARL W. OGLEBAY, Wheeling** June 30, 1929
W. C. COOK, Welch June 30, 1930
J. B. McLAUGHLIN, Strange Creek June 30, 1931

The State Board of Education has charge of all matters of a purely scholastic nature concerning the state educational institutions.

NOTICE

West Virginia University publishes a catalog of over 400 pages as well as smaller bulletins descriptive of each of the various colleges and schools. Requests for copies of these publications and inquiries for information about the University and its work should be addressed to

THE PRESIDENT'S OFFICE,
West Virginia University,
Morgantown, W. Va.

*Deceased.

CONSERVATION OF BITUMINOUS COAL AND ACCOMPANYING CARBONACEOUS MATTER*

By EARL R. SCHEFFEL

The layman usually takes literally the statement that a certain percentage of the coal in a given mine is recovered for use. As a matter of fact recovery estimates almost always ignore the coal in a given bed which is considered too poor for sale, and likewise neglects thin associated seams, bony coals and carbonaceous shales, as well as coals some distance above which may be rendered useless, or future mining operations more costly, through caving caused by removal of the coal below. Such associated carbonaceous materials may considerably exceed in carbon content the coal mined for sale.

Very little attention has been paid to wastes of this sort either in theory or practice.¹

Before discussing coal wastes further, it should be made clear that the recent extended investigations on "Oil Shales" have only indirect bearing on the present problem. The carbonaceous content of these so called "Oil Shales" is chemically different from that in ordinary bituminous coal, though resembling that in cannel coals.²

No accurate estimate may be made from data now available regarding such wastes, as coal sections are unfortunately

*This article is a slightly modified summary of a somewhat comprehensive treatment of this subject by the same writer.

The writer is particularly indebted for instructive information, or valuable references to Dr. Reinhardt Thiessen, Bureau of Mines, Pittsburgh, Pa.; Rudolph Kudlich, Bureau of Mines, Washington, D. C.; F. M. Kingsbury, Division of Geology, Indiana; J. J. Rutledge, Chief Mine Engineer, Bureau of Mines, Maryland; Geo. H. Ashley, State Geologist, Pennsylvania, and others.

¹Some of the most vigorous criticisms of this waste or remedial suggestions appear in the 23rd Annual Report (1898) of the Indiana "Department of Geology and Mineral Resources" (pp. 1488-1490) in Bulletin 13, (1911) U. S. Bureau of Mines "Resumé of Producer-Gas Investigations" (pp 2, 10, 40, 42) and in Volume II (1903) "Coal" of the West Virginia Geological Survey (pp 167, 538-539).

²For an excellent discussion of the relative oil-producing values of "Oil Shales," bituminous and cannel coals, with specific data, see "Oil Resources in Coals and Carbonaceous Shales of Pennsylvania" by Chas. R. Fettke; a Report of the Pennsylvania Geological Survey, Geo. H. Ashley, State Geologist, Harrisburg, Pa.

generally described without a thorough consideration of this problem. Nevertheless, some approximation may be made of the quantity of such waste in certain regions. Dr. I. C. White estimated (1911) that West Virginia can produce about twenty billion tons of low grade or bony coal with heating value of about 10,000 B. T. U. per pound. This is about one-third of his estimate for the present commercial grade coals of the state. If to this estimate be added carbonaceous deposits of still lower grade, up to 50 per cent ash, it is probable the estimate would be greatly increased.

One estimate gives the Pittsburgh coal a workable area of about 6,000 square miles. Usually within a few feet above this coal are a number of thin beds, which sometimes aggregate as much as four feet in thickness. Allowing a conservative average of two feet for these coals over the entire Pittsburgh area, a tonnage is computed of approximately twelve billion, or about one-fourth of the Pittsburgh coal proper, which has been considered alone in past estimates of recovery. Locally, the Redstone coal is found about forty feet above the Pittsburgh, and the Sewickley about 100 feet above. These coals, sometimes aggregating ten feet in thickness, may be badly damaged or rendered irrecoverable by the removal of the Pittsburgh first, a usual practice as this is the most valuable of the three coals.

The Pittsburgh coal is used merely as an example. There are few coal areas which do not show a similar condition, but varying in degree.

It is admitted that present mining conditions in much of the bituminous coal area offer little hope for immediate utilization of such carbonaceous materials made irrecoverable by present methods. As one practical geologist remarked, "the margin of profit is often precarious now, without being further jeopardized by costlier methods." However, it must be remembered that the coals now being mined are usually those most easily secured, and that the wasted materials rank hardly more than second in ease of recovery.

Should attempts be made to save such coals and carbonaceous wastes, their utilization would constitute a problem. As they usually have poor fuel value and the cost of recovery is relatively high, special disposition may be necessitated if they are to become economically profitable. Unable to compete on distant markets with better grade fuels, it is probable that utilization at the mine will be the only solution.

SUGGESTED UTILIZATIONS AT THE MINES

Producer Gas. The Bureau of Mines¹ has shown that bony coals with ash as high as 44 per cent have had their carbonaceous matter successfully converted into producer gas. Such materials used in this way develop two and one-half times the power that would have been secured under the ordinary steam boiler. Bony coals so used may actually develop energy equal or superior to high grade coals used directly for steam production. Much of the producer gas could be used locally. It is possible the excess might be transported, especially in the Appalachian district, by pipe lines now used for the transportation of petroleum and natural gas, especially after the supplies of these natural resources wane.

Destructive Distillation. Two methods are now in use; the high and the low temperature. It is agreed that any great increase in the destructive distillation of carbonaceous matter would tend to depress prices of coke and by-products, yet it might well happen that such depression would stimulate uses to such an extent as to check such tendency before it resulted in disaster.

Petroleum Substitute. Experiments in Germany indicate the possibility of converting 90 per cent of coal into a fuel oil by chemical methods, and that this may be made to yield by further treatment 40 per cent of its volume in light oil and gasoline. By present methods of destructive distillation comparatively little oil is secured from bituminous coal, though

¹U. S. Bureau of Mines Bulletin 13, p. 40.

cannel coals were a considerable source in this country of an oil resembling petroleum during the decade 1850-1860. If the German method proves economically feasible, these low grade coals have a prospect of easily competing with the much mooted "Oil Shales" of the west, which are often located in almost inaccessible regions, with inadequate water supplies, ash content usually higher than the wastes we are considering, and located at great distance from refineries and large consuming markets. With our present known fields of petroleum undergoing rapid depletion, and the discovery of new fields increasing in costliness, a market may be expected to come into existence for an enormous quantity of satisfactory substitute.

Mechanical Beneficiation. Washing bituminous coals of low grade will in some cases greatly reduce the ash content. While washing is by no means unknown in the bituminous industry, it is probable this method could be extended in use to great advantage.

Increasing height of roof by mining thin associated seams will often give a mining advantage which will partially compensate for the poor quality of this additional material. In some cases removal of fire clay will give similar advantage. Such clay may more than pay for its removal.

Conversion into Electric Energy. Whether by direct combustion of the coal, or burning of by-products, conversion into electric energy may in some cases prove feasible. This has often been discussed as a method of reducing transportation costs even of high grade coals. Generation of electricity at the mines for transportation elsewhere is already on a practical basis.⁴ The cost of transmitting electricity would be the same without reference to the grade of coal used in its generation. As the better coals can stand transportation costs, it may well work out in the future that only good coal will be

⁴Literary Digest, April 3, 1926, p. 23. Copied by the Digest from an article in the Baltimore Sun by Raymond Kenny.

shipped while those coals and carbonaceous materials⁵ which cannot stand transportation costs may be converted into electricity at the mine, if other utilizations suggested are found less practical.

⁵The term carbonaceous materials is used in this article on account of the the low grade fuels or wastes. One suggestion has been made that coal with little carbon be called stone; with less than 40 per cent carbon, slate; with 40 to 65 per cent carbon, bone; and with 65 or more per cent carbon, coal. The geologist in the field may have to devise a nomenclature of his own which will be descriptive of the coal and perhaps suggestive of its chemical character, leaving indefiniteness of coal nomenclature. Many different terms are used to designate to the chemist a classification of the sort indicated.

PREDICABLE VALUE OF INTELLIGENCE TESTS

L. B. HILL, Professor of Education

In October, 1923, the Thorndike Intelligence Examination was given to 548 freshmen in West Virginia University. This examination consists of five parts including the fore-exercise, or practice form. The actual working time for the examination is two hours and fifty minutes. Allowing time for explanations, distribution of papers, and a rest period, three and one-half ($3\frac{1}{2}$) hours are necessary for the examination. The author of the test says that the scores should vary from about 40 to 100 with an occasional record above 100. The scores for the University freshmen in 1923 ranged from 15.2 to 104.7 with a median of 56.8. The following table shows the frequencies of scores, also the percentage of frequencies from which it may be seen that approximately one-eighth (68) of the West Virginia University freshmen score at forty or below and that one-half (274) fail to reach or exceed a score of 56.8.

Freshmen in West Virginia University, 1923		
Scores	No.	Per Cent
10 to 19	3	.005
20 to 29	9	.016
30 to 39	57	.104
40 to 49	104	.189
50 to 59	147	.268
60 to 69	110	.200
70 to 79	72	.131
80 to 89	29	.053
90 to 99	15	.027
100 or over	2	.003

Median 56.8

What happened to these students during the first semester 1923-24? Of the 548 who took the examination 92 dropped out before the end of the semester. Of the 92 who dropped out 20 were from those whose intelligence scores were in the low seventh of the group, 22 in the upper seventh. Exactly

46 pupils, one-half of those who dropped out, had intelligence scores which reached or fell below and the same number exceeded the median score. It would seem that a low intelligence score is in no way responsible for the voluntary withdrawal of students or for their failure to be reinstated at mid-semester, since the same number of students with high intelligence scores withdrew voluntarily or were not reinstated as those with low intelligence scores. This fact might be interpreted in different ways; it might be inferred that students with low mentality possess as much grit and stick-to-it-iveness as those with a high degree of mentality; or, that the intellectual appeal of the university is no greater to students of high mentality than to students of low mentality.

Of the total number of failures at the end of the first semester intelligence scores are available for seventy-six. Of this number sixty fell below the median score of the entire group while sixteen reached or exceeded this score. The median score of this group of pupils is 46.6.

The most helpful and interesting part of this study is found in the relationship between the intelligence scores and the academic grades at the end of the semester. The Parson Coefficient of Correlation which measures the relationship between the intelligence scores and semester grades is .43. This is not considered a high correlation, but is sufficient to suggest further study.

Its significance may be further seen in the following statements:

Pupils who made 40 or less on the intelligence examination (approximately one-eighth of the group) have academic grades ranging from 50 to 85 with a median of 72.5. Pupils who made 76 or more on the intelligence examination (approximately one-eighth of the group) have academic semester averages ranging from 64 to 93 with a median of 82.1. The low fourth of the group whose intelligence scores range from 15.2 to 46.7 have average academic grades ranging from 50

to 87 with a median of 72.6. The upper fourth of the pupils whose intelligence scores range from 76.1 to 100.5 have average academic grades ranging from 60 to 94 with a median of 81.6. Of all the pupils whose intelligence scores equals or exceeds the median of the group only 17 have academic averages at the end of the semester of less than 70. Of the pupils whose intelligence scores fall below the median of the group 55 have average academic grades of less than 70.

The following table shows the percentage distribution of academic averages of the 456 freshmen who completed the first semester's work so arranged as to indicate what per cent of the entire class obtained or exceeded certain academic averages at the end of the semester of less than 70. Of the pupils whose intelligence scores fall below the median of the group 55 have average academic grades of less than 70. It also shows percentage distributions of those who scored high (76 or above), and those who scored low (40 or less) on the intelligence scale.

Academic Average Grade obtained or exceeded	Freshmen who re- ceived semester grades—456.	Intelligence Score	
		High Freshmen (76 or above)	Low Freshmen (40 or less)
50	100	100	100
55	98.4	100	93.3
60	97.0	98.3	90.0
65	91.7	98.3	76.6
70	84.6	98.3	65.0
75	57.0	79.7	20.8
80	37.7	61.0	8.3
85	12.0	35.6	1.6
90	2.3	8.5	0.0

The foregoing table reads: 100 per cent of the entire class received an average of 50 or above; 98.4 per cent received an academic average of 55 or above. Approximately 80 per cent of the high freshmen received an academic average of 75, or above; only 20 per cent of the low freshmen received similar averages.

The correlation between the intelligence scores and average grades for the semester is by no means perfect. It is sufficiently high to challenge further study and investigation. More especially is this true since the academic grades are not infallible. Intelligence scores in the hands of class officers when programs of study are assigned should remind one that a student with a score of 40 or below on the Thorndike Intelligence Examination, has only one chance in five of making an average of 75 per cent on his semester's work in West Virginia University. A student with an intelligence score of 76 or above has four chances out of five of making an average of 75 per cent or above. Owing to these facts it seems reasonable that great care should be taken in the assignment of work to students. Since students with low intelligence scores display as much determination to succeed as those with high scores the class officer needs a knowledge of the students' past history. This could be obtained from parents, teachers, high school principals, and superintendents. A careful statement from the high school principal should be particularly helpful.

THE NATURAL METHYL ANTHRAQUINONE
DERIVATIVES

JOHN H. GARDNER

The anthraquinone derivatives occurring in plants early attracted the attention of chemists, partly because of their importance and partly because they are comparatively easily obtained in a crystalline condition suitable for convenient study. A number of these compounds have found practical use as dyes since prehistoric times, notably alizarine, familiar as the coloring matter of our two cent stamps, and morindone, one of the most important dyestuffs in India. Others are found in many of the most used and least understood drugs, the purgatives, such as aloin, rhubarb, and cascara sagrada.

The most important compounds of this class found in nature are the hydroxy-derivatives of anthraquinone and of the methyl anthraquinones. The methods of isolation and the most important sources are described quite completely by Perkin and Everest.¹ The syntheses of the most important hydroxy anthraquinones were early accomplished, and the methods have been reviewed very completely by Barnett.² However, it is only within the last five years that any of the naturally occurring hydroxy methyl anthraquinones have been synthesized, several still remaining of uncertain constitution. It is with these compounds that this review will deal.

The methyl anthraquinone derivative which has been most extensively studied is emodin, a trihydroxy methyl anthraquinone which occurs in many of the most important purgatives. It appears to have been discovered in a study of the constitution of rhubarb by de la Rue and Miller in 1858.³ It has since been shown to be present in frangula⁴ and cascara

¹The Natural Organic Coloring Matters, London and New York, 1916, Chapter I.

²Anthracene and Anthraquinone, New York, 1921, Chapter XII.

³J. Chem. Soc. 10, 296. (1858).

⁴Abbreviations used in literature citations are those of chemical abstracts. See C. A. October 20, 1922, supplementary section.

⁵Liebermann and Waldstein, Ber. 9, 1775, (1876).

sagrada,⁸ probably occurring in each case as a glucoside⁹ (in It has since been shown to be present in frangula⁴ and cascara the general sense). In many of the plants, the sugar combined with emodin is rhamnose.⁷

A dihydroxy methyl anthraquinone, chrysophanic acid, frequently accompanies emodin. A third related compound, frequently found associated with emodin and chrysophanic acid is aloë-emodin, an isomer of the former. Chrysophanic acid occurs in greater or less quantities in all emodin-bearing plants, with aloë-emodin frequently being noted as present in traces. The last is formed in practical quantities in aloes, as the name implies, in which it forms a unit of the crystalline constituent, aloin. While it is by no means certain that the aloins obtained from the various varieties of aloes are chemically identical, in the writer's opinion the best published work makes this conclusion appear highly probable.⁸ According to Léger, aloin is a d-arabinoside of aloë-emodin,⁹ a view strongly supported by the work of Seel and Kelber,¹⁰ who showed that the molecular weight of aloin in solution agrees with the formula calculated on the basis of Léger's results.

Since these three compounds are so closely related in their occurrence, one might reasonably expect them to be closely related in their chemical constitution. A review of the most important work on the determination of their structural formulas will show the conclusion to be justified.

In 1870, Graebe and Liebermann distilled chrysophanic acid with zinc dust, obtaining a hydrocarbon which they believed to be anthracene.¹¹ A repetition of the experiment with chrysophanic acid and with emodin by Liebermann in 1876 showed that, contrary to their previous conclusions, both compounds yielded a methyl anthracene, which, on oxidation,

⁸Schwabe, Ber. 21, (2), 842, (1886).

⁹(a) Thorpe and Robinson, J. Chem. Soc. 57, 38, (1890).

(b) Kubly, Pharm. Zeit. für Russland 8, 160, (1866).

⁷Thorpe and Miller, J. Chem. Soc. 61, 1, (1892).

⁸See, for example, Cathercoal and Teny, J. Am. Pharm. Assoc. 11, 523, (1922).

⁹Compt. rend. 180, 1695, (1910).

¹⁰Ber. 49, 2364, (1916).

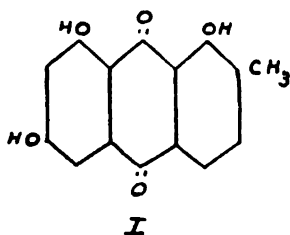
¹¹Ann. Suppl. 7, 257, (1870).

¹²Ann. 183, 159, (1876).

gave an anthraquinone carboxylic acid.¹³ In the previous year, Schmidt had obtained the same hydrocarbon from an aloin isolated from Barbados aloes.¹⁴ In 1908 Oesterle and Tisza showed that the methyl group is in the B-position.¹⁵

Three years later, Oesterle succeeded in reducing aloemodin to chrysophanic acid, and in oxidizing both compounds to the same dihydroxy anthraquinone carboxylic acid, rhein,¹⁶ a compound previously isolated many times in preparations containing chrysophanic acid and aloemodin. From this, he concluded that chrysophanic acid must be a dihydroxy-B-methyl anthraquinone, and aloemodin the corresponding carbinol, since the latter contains one more atom of oxygen than the former.

In the same year, Oesterle with Sypkens-Toxopeus studied the reaction of emodin with ethyl chloroacetate and concluded that two of the three hydroxyl groups must be in the 1:8 positions, the third in a B-position.¹⁷ Since emodin does not act as a mordant dyestuff, it appeared probable that two of the hydroxyls must be in meta-positions with respect to each other.¹⁷ As a consequence, Oesterle and Sypkens-Toxopeus assigned to emodin the structure 1:6:8-trihydroxy-2-methyl anthraquinone (Formula I).



¹³Ber. 8, 1275, (1875).

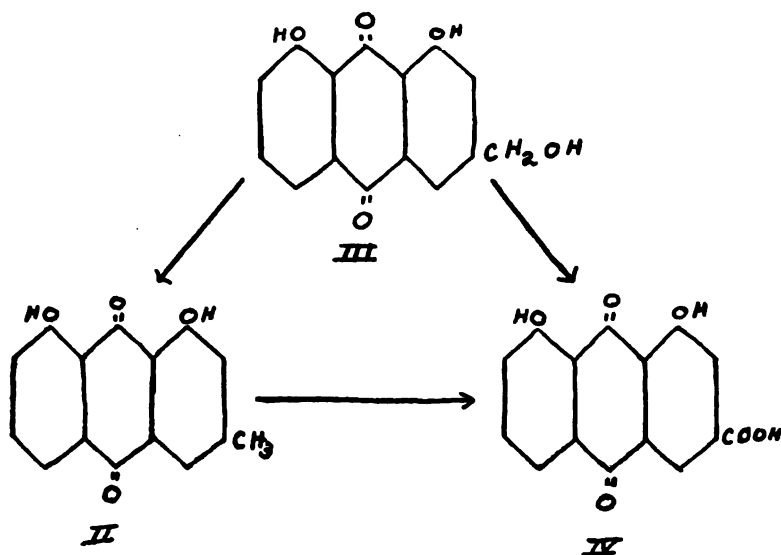
¹⁴Arch. Pharm. 246, 432, (1908).

¹⁵Arch. Pharm. 248, 445, (1911).

¹⁶Arch. Pharm. 248, 311, (1911).

¹⁷Rule of Liebermann and Kostaneki. See Cain and Thorpe, *Synthetic Dyestuffs*, Fourth Edition, London, 1918, page 42.

Oesterle had previously shown that rhein, on decarboxylation, yields 1:8 dihydroxy anthraquinone.¹² He next succeeded in replacing the carboxyl group of rhein by hydroxyl, obtaining 1:3:8-trihydroxy anthraquinone.¹³ As a consequence, we can express the relationship between chrysophanic acid (II) aloë-emodin (III) and rhein (IV) in the structural formulas:



By analogy one would expect the methyl group of emodin to be in the 3- rather than the 2- position, a conclusion borne out by synthesis, as will be described later.

During the last few years, the attention of investigators in this field has been largely directed toward devising methods for the synthesis of the various methyl anthraquinone derivatives found in nature. The most common methods for the preparation of hydroxy anthraquinone derivatives are of no value in this case as the rules of orientation in the anthraquinone series are too complex and too poorly understood to make possible the prediction of results. Consequently, it has

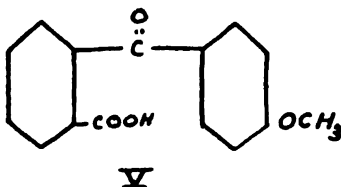
¹²Arch. Pharm. 230, 305, (1912).

been found necessary to develop a new technique, although one involving merely an amplification of old methods.

In 1874, Behr and van Dorp prepared anthraquinone by dehydrating *o*-benzoyl benzoic acid, at that time a very difficult compound to prepare, with phosphorus pentoxide.¹⁸ Four years later, Friedel and Crafts found that the acid could easily be prepared by condensing phthalic anhydride with benzene by means of aluminum chloride.¹⁹ In the meantime, Lieberman had improved the process by substituting sulfuric acid for phosphorus pentoxide, as the dehydrating agent.²⁰ Since then, the reaction has been extended to include a large number of substitution products of both the anhydride and benzene.

It will be noted that, according to Oesterle's formula, chrysophanic acid contains one hydroxyl group in one benzenoid ring, and a hydroxyl and a methyl in the other. Such a structure should be obtainable by condensing the suitable hydroxy phthalic anhydride (or an anhydride containing a group replacable by hydroxyl) with *m*-cresol. Similarly, the other compounds of this class should be obtained by condensing suitable anhydrides with cresols, or cresol ethers. Before the syntheses could be carried out, however, it was necessary to study the general procedure, to determine the rules of orientation and the experimental details of the methods giving the best results.

Nourisson condensed phthalic anhydride with anisol, using aluminum chloride, and showed that the condensation took place in the para position to the methoxyl group of the anisol, giving *o*-(4-methoxy benzoyl)-benzoic acid (V)²¹



That this orientation is general has been shown in studies with the cresol methyl ethers by Bentley, Gardner and Weizmann,²² and by the writer and Adams.²³

¹⁸Ber. 7, 576, 1874.

¹⁹Compt rend. 86, 1368, (1878).

²⁰Ber. 7, 805, (1874).

²¹Ber. 10, 2103, (1886).

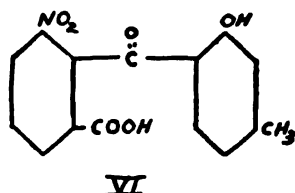
²²J. Chem. Soc. 91, 1626, (1907).

²³J. Am. Chem. Soc. 45, 2455, (1923).

Ullmann and Schmidt found that phthalic anhydride will condense with free phenols, using aluminum chloride as a condensing agent and acetylene tetrachloride as a solvent.²⁶ In this case, the condensation takes place in the ortho position to the hydroxyl for the most part, only small amounts of the compounds corresponding to the type of Formula V being obtained.

Unfortunately, acetylene tetrachloride cannot be used as a solvent with some substituted phthalic anhydrides as it causes the decomposition of the anhydride.²⁷ Consequently, Graves and Adams undertook the study of this reaction using an excess of the phenol as a solvent.²⁸ They found the orientation to be the same as in Ullman and Schmidt's experiments.

Using the method of Ullman and Schmidt, in 1922, Eder and Widmer condensed 3-nitro phthalic anhydride with *m*-cresol; obtaining the substituted *o*-benzoyl benzoic acid represented in Formula VI.²⁹ The nitro group was then reduced to the amine, and converted into hydroxyl by the diazo reaction. On dehydration with sulfuric acid, chrysophanic acid was produced, confirming Oesterle's formula.



An application of the same procedure by the same workers using 3:5 dinitro phthalic anhydride and *m*-cresol resulted in the synthesis of emodin,³⁰ which was also synthesized independently, but somewhat later, by Jacobson and Adams, who condensed 3:5 dimethoxy phthalic anhydride with *m*-cresol,³¹ using the method of Graves and Adams.²⁸ In this case, direct dehydration with sulfuric acid was found unsatisfactory, no

²⁶Ber. 52, 2096, (1919), and Schmidt, Dissertation, Berlin, (1920).

²⁷Gardner, Thesis, University of Illinois, 1923.

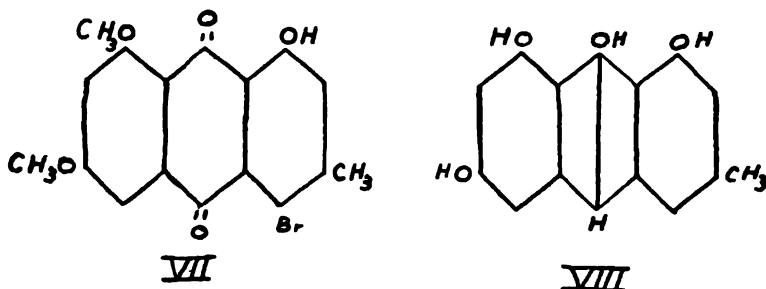
²⁸J. Am. Chem. Soc. 45, 2440, (1923).

²⁹Helvetica Chem. Acta 5, 3, (1922).

³⁰Helvetica Chem. Acta 6, 916, (1923).

³¹J. Am. Chem. Soc. 46, 1312, (1924).

more than traces of the anthraquinone derivative being obtained, a difficulty frequently encountered when the dehydration must take place in the meta position with respect to two negative groups.^{23, 24, 25} The conversion to an anthraquinone derivative was accomplished indirectly by brominating the benzoyl benzoic acid and then dehydrating, producing a bromo-emodin dimethyl ether. (Formula VII). This compound was then



treated with HI, the bromine being removed, the methoxy groups hydrolyzed, and the central ring reduced to an anthranol (Formula VIII) simultaneously. An oxidation, emodin was obtained.

From these syntheses, Oesterle's formulas for chrysophanic acid and emodin have been definitely established, leaving little possibility of doubt as to the correctness of the structures given for the related compounds, aloë-emodin and rhein. The final confirmation by synthesis is alone lacking.

Since aloë-emodin is an anthraquinone carbinol, a class of compounds about which practically nothing is known at present, it will be necessary to modify the usual methods in order to effect its synthesis. This problem is to be investigated by the writer during the coming year.

Recently, another important methyl anthraquinone derivative, morindone, has been synthesized by Jacobson and Adams.²⁶ Since the literature regarding this compound is fully reviewed in the paper describing its synthesis, and since it is of no economic importance in this country, we will omit it from the discussion here.

²³J. Am. Chem. Soc. 47, 283, (1925).

A THEORY OF WIRELESS PROPAGATION

R. C. COLWELL

It has been known for many years that with distances above one hundred miles over seas, the Austin Cohen formula is approximately correct by day. In 1923, it was shown by the measurements of Bown that the absorption factor disappeared by night. The theory was then developed according to which the waves from a wireless antenna passed out in all directions from the antenna but were guided by the ground around the spherical earth. By night there was no absorption, hence the received signal followed the Hertzian formula but by day the ionized air absorbed much energy from the wave-giving the Austin Cohen formula. There were two objections to this theory—first, the known ionization of the air could not account for the amount of absorption; second, by night the received signal fluctuated violently and did not follow the Hertzian formula very closely.

Meantime, other physicists had attempted to account for the bending of wireless waves around the earth by some kind of diffraction, but Watson and Von der Pol showed that diffraction could only account for a very small part of the received signal. Hence in 1923, Larmor modified the Eccles theory of the Heaviside Layer and showed mathematically that a certain ionization in the upper air at heights from 50 to 100 miles would cause wireless waves to bend around the earth.

At the present time there has been a union of the two theories. Physicists now believe that part of the radiation from a sending antenna is guided by the surface of the earth while a greater part of it is radiated into space. By day the space wave is absorbed or is unreflected so that it does not reach the receiving antenna which is then acted upon by the surface wave. At night the Heaviside Layer comes into action and the space wave is reflected or refracted back to the earth and thus adds to or subtracts from the surface wave according to the phase. Since the Heaviside Layer is not

fixed or regular, the reflected wave will be irregular and so give rise to the well known fluctuations or fading.

All theories so far have assumed that the surface wave and the space wave are independent; that is the antenna radiates as in Figure 1.

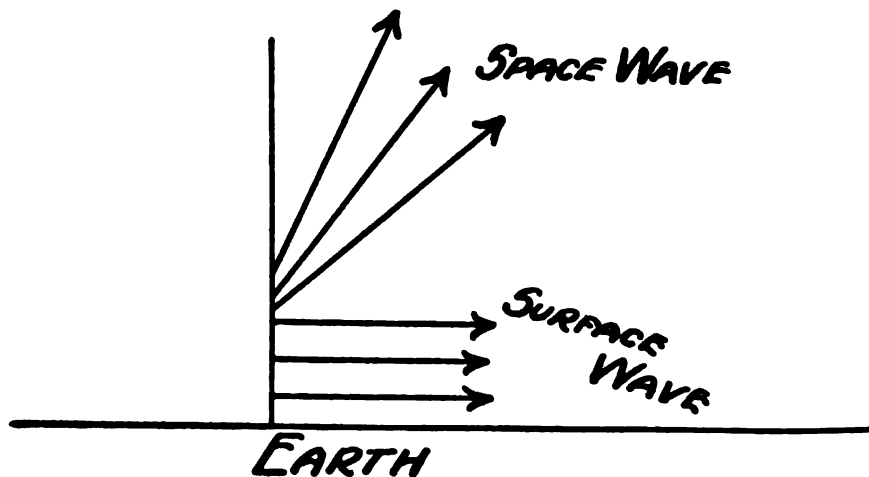


FIG. 1

The theory here outlined assumes that the space wave is formed from the surface wave as the radiation passes along the ground. Close to the antenna, there is no radiation into space but at great distances the space wave becomes predominant.

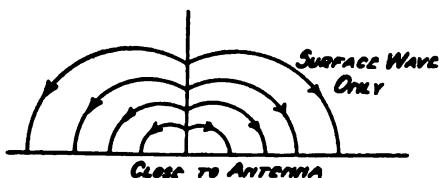


FIG. 2

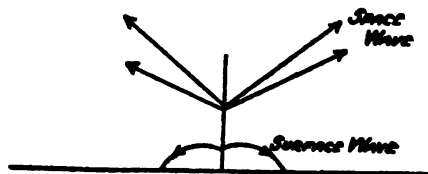


FIG. 3
AT A CONSIDERABLE DISTANCE FROM
THE ANTENNA.

The surface wave clings to the earth because of the electric currents generated in the ground by the sending antenna. As these ground currents are dissipated by the resistance of the ground the surface wave changes to a space wave (Figures 2 to 4.)

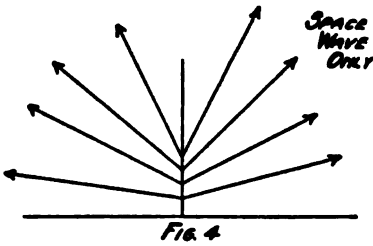


FIG. 4

AT VERY GREAT DISTANCES FROM THE ANTENNA.

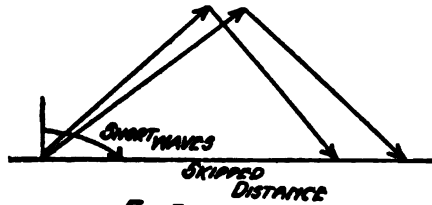


FIG. 5

According to this theory, there should be no fading close to the antenna not because the Heaviside Layer will not reflect the wave reaching it at sharp angles (the usual theory) but because there is no radiation going up to the Heaviside Layer at short distances. The short wave signals die out rapidly not because the energy is absorbed by the ground but because the space wave soon predominates. Therefore, for short waves, a sharp concentrated cone of radiation is thrown up to Heaviside Layer. This is returned to the earth at a very great distance. According to this theory a short wave over poorly conducting ground should throw up a sharper cone than over sea (a good conductor), hence, short wave reception should be better over land than over sea. The very long waves never quite lose contact with the ground, that is the surface wave predominates over the space wave hence there is little difference between day and night reception for long waves (20,000 meters). Waves of medium length 200 to 1000 meters have space and surface waves approximately equal; hence they have most fluctuation and fading.

A simple mathematical formula based on the Austin Cohen equation will summarize the above discussion. The

Hertzian formula for the current in a receiving aerial is:

$$I_r = I_s \frac{188h_s h_r}{R\lambda x} \quad (1)$$

Where I_r — received current

I_s — sending current

h_s — height of sending antenna

h_r — height of receiving antenna

R — resistance of receiving antenna

λ — wave length

x — distance in kilometers

The Austin Cohen formula introduces a factor $E^{-0.015}$

$\sqrt{\frac{x}{\lambda}}$ It is the essence of the theory here outlined that this factor does not represent absorption but represents the proportion of the surface wave which has not been changed into space wave. Hence

$$I_r = I_s \frac{188h_s h_r}{R\lambda x} \left[E^{-0.015} \frac{x}{\sqrt{\lambda}} \right] \quad (2)$$

is the received current from the surface wave while

$$I_s \frac{188h_r h_r}{R\lambda x} \left[1 - E^{-0.015} \frac{x}{\sqrt{\lambda}} \right] \quad (3)$$

represents the space wave. By day only (2) is in action but by night the radiation represented by (3) is returned to the earth by reflection (Larmor) from the Heaviside Layer. There may be multiple reflection. (Figure 6.)

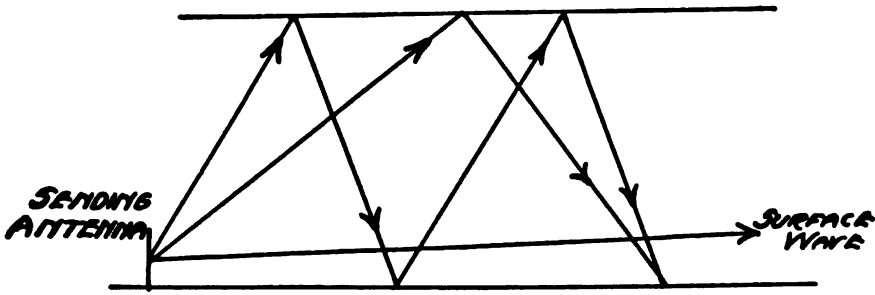


FIG. 6 MULTIPLE REFLECTION

Then if the earth is regarded as a perfect reflector while the Heaviside Layer has a certain absorption factor, the total received radiation will take the form

$$I_r = I_s \frac{188 h_s h_r}{R \lambda x} \left[1 + (1 - E^{-.0015 \frac{x}{\sqrt{\lambda}}}) \left(s + s^2 + s^3 \right) \right] \quad (4)$$

where "s" is some fraction. Now "s" may be variable, hence the fluctuations at night.

SOME THEOREMS ON THE ZEROS OF SOLUTIONS OF
SELF-ADJOINT HOMOGENEOUS LINEAR DIFFERENTIAL
EQUATIONS OF THE
FIFTH ORDER

CLARENCE N. REYNOLDS, JR.

The most general self-adjoint homogeneous linear differential equation of the fifth order with no singular points may be put in the form

$$(1) \quad L_5(u) \equiv u^{iv} + 20p_2 u''' + 30p_2' u'' + (30p_2'' + 100p_2^2 - 4p_4) u' + (10p_2''' + 100p_2 p_2' - 2p_4') u = 0, \quad a \leq x \leq b,$$

by a linear transformation of the dependent variable. This equation is satisfied by $y_1 y_2' - y_2 y_1'$ whenever y_1 and y_2 are solutions of the equation.

(2) $L_4(y) \equiv y^{iv} + 10p_2 y''' + 10p_2' y'' + p_4 y' = 0, \quad a \leq x \leq b.$ In studying the solutions of (1) it will be sufficient for our purposes if we assume $p_2(x)$, $p_2'(x)$, $p_2''(x)$, $p_2'''(x)$, $p_4(x)$, and $p_4'(x)$ continuous functions of x in our interval.

If $u_1(x)$ and $u_2(x)$ satisfy (1), then there will exist a bilinear form $P_5(u_1, u_2)$ in the u 's and their first four derivatives such that

$$\frac{d}{dx} P_5(u_1, u_2) \equiv u_2 L_5(u_1) + u_1 L_5(u_2) = 0.$$

This identity is due to Lagrange.* Similarly if $y_1(x)$ and $y_2(x)$ satisfy (2), there exists a bilinear form in the y 's and their first three derivatives, $P_4(y_1, y_2)$, such that

$$\frac{d}{dx} P_4(y_1, y_2) \equiv y_2 L_4(y_1) - y_1 L_4(y_2) = 0.$$

These constant bilinear forms, when evaluated explicitly, are

$$\begin{aligned} P_5(u_1, u_2) &\equiv u_1^{iv} u_2 - u_1''' u_2' + u_1'' u_2'' - u_1' u_2''' + u_1 u_2^{iv} \\ &\quad + 20p_2(u_1'' u_2' - u_1' u_2'') + 10p_2'(u_1' u_2 + u_1 u_2') \\ &\quad + (20p_2'' + 100p_2^2 - 4p_4) u_1 u_2, \\ P_4(y_1, y_2) &\equiv y_1''' y_2 - y_1'' y_2' + y_1' y_2'' - y_1 y_2''' + 10p_2(y_1' y_2 \\ &\quad - y_1 y_2'). \end{aligned}$$

* cf. Bôcher, "Leçons sur les Méthodes de Sturm, etc." Paris, 1917, sec. 6, chap. 2. Also Darboux, "Leçons sur la Théorie Générale des Surfaces," Paris, 1915, chap. 5, vol. 2.

In particular, if $u_1 \equiv 2$,

$$P_8(u_1, u_1) = 2u_1 u_1'' - 2u_1' u_1''' + u_1''^2 + 20p_2(2u_1 u_1'' - u_1'^2) \\ + 20p_2' u_1 u_1' + (20p_2'' + 100p_2^2 - 4p_4)u_1^2.$$

These constants determine some of the characteristic features of the solution to which they belong. For example no solution $u_1(x)$ of (1) for which $P_8(u_1, u_1)$ is less than zero can have a multiple zero, since $u_1(\bar{x}) - u_1'(\bar{x}) = 0$ implies that $P_8(u_1, u_1) - u_1'^2(\bar{x}) \geq 0$.

Let $\bar{u}_i(x), i=1, 2, 3, 4, 5$; and $\bar{y}_i(x), i=1, 2, 3, 4$; be solutions of (1) and (2) respectively, defined by the following boundary conditions:

$$\bar{u}_i^{(i-1)}(\xi) = 1, \bar{u}_i^{(k-1)}(\xi) = 0, i, k=1, 2, 3, 4, 5, i \neq k, \quad a \leq \xi \leq b$$

$$\bar{y}_i^{(i-1)}(\xi) = 1, \bar{y}_i^{(k-1)}(\xi) = 0, i, k=1, 2, 3, 4, \quad i \neq k,$$

Then $w_{ij}(x) = \bar{y}_i \bar{y}_j' - \bar{y}_j \bar{y}_i'$, $i, j=1, 2, 3, 4$; $i < j$, are six solutions of (1). If we express $w_{ij}(x)$ linearly in terms of the $\bar{u}$'s by the formula

$$w_{ij}(x) = \sum_{k=0}^4 w_{ij}^{(k)}(\xi) \bar{u}_{k+1}(x)$$

we find that the matrix formed by the coefficients involved is of rank five. Hence the six w 's are linearly dependent upon a set of five linearly independent w 's, the linear relation being, in this case

$$(3) \quad w_{12} - w_{23} - 10p_2(\xi)w_{34} = 0.$$

The five functions $w_{12}, w_{13}, w_{14}, w_{24}, w_{34}$ are linearly independent and in terms of them we can express linearly any two solutions of (1), such as $u_1(x)$ and $u_2(x)$. By actual computation we find that the wronskian of any pair of w 's is a bilinear form in the $\bar{y}$'s and in three rowed wronskians of $\bar{y}$'s. Therefore, since the wronskian of any three $\bar{y}$'s satisfies the self-adjoint equation (2), it can be expressed linearly in the $\bar{y}$'s and the wronskian of any pair of w 's may be expressed as a homogeneous quadratic form in the $\bar{y}$'s. Therefore $u_1 u_2' - u_2 u_1'$, the wronskian of two linear combinations of w 's, will be a quadratic form in the $\bar{y}$'s which we will denote by $Q(u_1, u_2)$.

Upon completing the computations indicated in the last paragraph we have

$$(4) \quad Q(u_1, u_2) = \sum_{ij=1}^4 A_{ij} \bar{y}_i \bar{y}_j, \quad A_{ij} = A_{ji}$$

where the coefficients, expressed in terms of the values of $u_1(x)$ and $u_2(x)$ and their first four derivatives at $x = \xi$, are as follows:

$$\begin{aligned} A_{11} &= (u_1, u_2') = u_1(\xi) u_2'(\xi) - u_2(\xi) u_1'(\xi), \quad A_{12} = \frac{1}{2} (u_1, u_2'') \\ A_{13} &= (u_1', \varphi_2), \quad \text{where } \varphi_n(x) = \frac{1}{2} (u_n'' + 10p_2 u_n'), \quad n=1, 2. \\ A_{14} &= \frac{1}{2} (u_1', \varphi_2') + \frac{1}{2} (\varphi_1'' + 10p_2 u_1', u_2) \\ A_{22} &= -(\varphi_1', u_2') \\ A_{23} &= \frac{1}{2} (u_1, \varphi_2'') + \frac{1}{2} (u_1', \varphi_2') \\ A_{24} &= \frac{1}{2} (u_1'' - 10p_2 u_1, \varphi_2') \\ A_{33} &= (u_1', \varphi_2'' - p_4 u_2) \\ A_{34} &= \frac{1}{2} (u_1', \varphi_2'' - p_4 u_2) - 5p_2 (u_1', \varphi_2') \\ A_{44} &= (\varphi_1', \varphi_2'' + 10p_2 u_2' - p_4 u_2). \end{aligned}$$

If we let $\bar{y}_1(x), \bar{y}_2(x), \bar{y}_3(x), \bar{y}_4(x)$ be the homogeneous co-ordinates of a point in three dimensional space, then as x varies our point will trace out an integral curve of equation (2), which will also be represented in the homogeneous line co-ordinates $w_{ij}(x)$ of a variable tangent to the curve.

Equation (3) implies that the tangents to our curve are all members of a non-singular linear line complex. Since $u_n(x)$ is a linear combination of w 's, the necessary and sufficient condition that $u_n(x)$ should be equal to zero at a point on our curve is that the tangent to the curve at the point should belong to the linear line congruence which is common to the linear line complex mentioned above and a second linear line complex associated with our particular solution of (1), $u_n(x)$. The lines of the line complex (3) which also belong to the two line complexes associated with the functions $u_1(x)$ and $u_2(x)$ lie on a ruled quadric on which $u_1 = u_2 = 0$. Since $Q(u_1, u_2)$ vanishes when both u_1 and u_2 vanish, a part, at least, of the quadric surface represented by $Q(u_1, u_2) = 0$ is ruled. Therefore the entire surface is ruled and we know that $Q(u_1, u_2)$ is not a definite quadratic form of rank four in the $\bar{y}$'s. It is

therefore possible for $Q(u_1, u_2)$ to have zeros, and we may insert it in the first theorem of my earlier paper on equations of the n th order,* obtaining a general separation theorem for self-adjoint equations of the fifth order:

Theorem 1. Between two consecutive zeros of $u_1(x)$ at which $u_2(x)$ is different from zero there exists an odd number of zeros of $u_2(x)$ and $Q(u_1, u_2)$.

We may restate this theorem geometrically by giving the following description of our integral curve:

The tangents to the integral curve of (2) belong to the linear line complex (3). Given any two linear line congruences, C_1 and C_2 , belonging to the linear line complex (3), which have in common the rulings of a ruled quadric surface Q , then between two consecutive points on the curve (but not on Q) at which the tangent lies in C_1 there are an odd number of points at which the curve either has a tangent lying in C_2 or meets the quadric Q .

In some cases $Q(u_1, u_2)$ is a definite quadratic form of rank less than four. For example: $Q(w_{13}, w_{34}) \equiv y_3^2$ and $Q(w_{13} + w_{24}, w_{34}) \equiv y_3^2 + y_4^2$. In such cases the zero of $Q(u_1, u_2)$ will be of even multiplicity and we have the

Corollary. If $Q(u_1, u_2)$ is a definite quadratic form of rank less than four, then in any interval in which $u_1(x)$ and $u_2(x)$ have no zeros in common the zeros of $u_1(x)$ and the zeros of $u_2(x)$ alternate.

We shall now derive the necessary and sufficient condition that, given a non-identically vanishing solution of (1), $u_1(x)$, there exist two solutions of (2), $y_1(x)$ and $y_2(x)$, such that

$$(5) \quad u_1 \equiv y_1 y_2' - y_2 y_1'.$$

Upon differentiating (5) repeatedly, combining the derivatives as indicated at the left, and rearranging the terms, we have the system of identities:

*cf. Transactions of the American Mathematical Society, vol. 22 (1921), pp. 220-229.

$$(6a) \quad f \equiv y_1 y'_2 - (y'_1 y_2 + u_1) \equiv 0$$

$$(6b) \quad f' \equiv y_1 y'_2' - (y'_1 y_2 + u'_1) \equiv 0$$

$$(6c) \quad y_1 f'' - y'_1 f' + y_1' f \equiv y_1^2 y_2''' - y_1 (y_1'' y_2 + u_1'') + (y_1' u_1' - y_1' u_1) \equiv 0$$

$$(6d) \quad h \equiv \frac{1}{2} y_1^2 (f'' + 10 p_2 f)' - y_1' (y_1 f'' - y_1' f' + y_1'' f) \equiv y_1 (y_1' u_1' - y_1'' u_1) - y_1' (y_1' u_1 - y_1'' u_1) - y_1^2 \varphi_1' \equiv 0$$

$$(6e) \quad h' \equiv y_1 (y_1' u_1'' - y_1'' u_1') - (y_1' + 10 p_2 y_1) (y_1' u_1' - y_1'' u_1) - y_1^2 (\varphi_1' - p_4 u_1) \equiv 0$$

Integrating (6d) we have

$$(7) \quad y_1' u_1' - y_1'' u_1 \equiv y_1 (\varphi_1 + c)$$

Eliminating y_1'' from (6d) and (6e) and substituting $y_1 (\varphi_1 + c)$ for $y_1' u_1' - y_1'' u_1$ in the resulting identity, we have

$$(8) \quad y_1^{-2} (u_1' h - u_1 h') \equiv c^2 - \frac{1}{2} P_5(u_1, u_1) = 0$$

Therefore $P_5(u_1, u_1) \geq 0$ is a necessary condition that there exist solutions of (2), y_1 and y_2 , such that our given solution of (1), $u_1(x)$, shall be equal to the wronskian of y_1 and y_2 .

Now if $u_1(x)$ is a non-identically vanishing solution of (1), it may be defined by the values of $u_1(\xi)$, $u_1'(\xi)$, $u_1''(\xi)$, and $u_1'''(\xi)$, where ξ is any value of x for which $u_1(\xi) \neq 0$. If $P_5(u_1, u_1) \geq 0$ then a two parameter family of non identically vanishing solutions of (2) is defined by imposing upon the values of $y_1'(\xi)$ and $y_1''(\xi)$ the condition that they satisfy (6d) and

$$(7') \quad y_1' u_1' - y_1'' u_1 \equiv y_1 [\varphi_1 + \frac{1}{2} \sqrt{P_5(u_1, u_1)}]$$

Equation (6d) implies (7). (7) and (7') imply (8). (8) and (6d) imply (6e). Therefore (6d) and (6e) are equivalent to (6d) and (7').

We can now associate with our given $u_1(x)$, and any member of the family of y 's defined in the last paragraph which does not vanish for $x = \xi$, a second solution of (2), $y_2(x)$, defined by any set of values of $y_2(\xi)$, $y_2'(\xi)$, $y_2''(\xi)$, and $y_2'''(\xi)$ which satisfy equations (6a, b, c). Equations (6a, b, c, d, e) now imply that the function $y_1(x) y_2'(x) - y_1'(x) y_2(x)$, which is known to satisfy (1), will satisfy the boundary conditions at $x = \xi$ which define $u_1(x)$. Therefore

$u_1(x) \equiv y_1(x)y_2'(x) - y_1'(x)y_2(x)$, and we have

Theorem 2. The necessary and sufficient condition that it be possible to express a non identically vanishing solution of (1) in the form (5), in which $y_1(x)$ and $y_2(x)$ are solutions of (2), is that $P_5(u_1, u_1) \geq 0$.

If we have two linearly independent solutions of (1), $u_1(x)$ and $u_2(x)$, then there exists a ξ such that $u_1(\xi) \neq 0$, $u_2(\xi) \neq 0$, $u_1(\xi)u_2'(\xi) - u_1'(\xi)u_2(\xi) \neq 0$. If $P_5(u_n, u_n) \geq 0$, $n=1, 2$; then there exist solutions of (2), $y_1(x)$, $y_2(x)$, $y_3(x)$ and $y_4(x)$, such that

$$u_1(x) \equiv y_1(x)y_2'(x) - y_1'(x)y_2(x),$$

and

$$u_2(x) \equiv y_3(x)y_4'(x) - y_3'(x)y_4(x).$$

These solutions of (2) may be determined by the values of their derivatives at $x \equiv \xi$, which are to be found by solving (6a, b, c, d) and (7'). One set of values satisfying these conditions is:

$$y_1 = 1, \quad y_1' = 0, \quad y_1'' = -u_1^{-1}(\varphi_1 \pm \frac{1}{2} \sqrt{P_5(u_1, u_1)}), \quad y_1''' = -u_1^{-1}\varphi_1';$$

$$y_2 = 0, \quad y_2' = u_1, \quad y_2'' = u_1', \quad y_2''' = u_1'' - (\varphi_1 \mp \frac{1}{2} \sqrt{P_5(u_1, u_1)});$$

$$y_3 = 1, \quad y_3' = 0, \quad y_3'' = -u_2^{-1}(\varphi_2 \pm \frac{1}{2} \sqrt{P_5(u_2, u_2)}), \quad y_3''' = -u_2^{-1}\varphi_2';$$

$$y_4 = 0, \quad y_4' = u_2, \quad y_4'' = u_2', \quad y_4''' = u_2'' - (\varphi_2 \mp \frac{1}{2} \sqrt{P_5(u_2, u_2)}).$$

Let us call the matrix of these quantities M . Then the rank of M is at least three, since the value of the three rowed determinant in the lower left hand corner of M is $u_2(\xi)u_1'(\xi) - u_2'(\xi)u_1(\xi)$, which is different from zero by our choice of ξ . Therefore the necessary and sufficient condition that it be possible to express $u_1(x)$ and $u_2(x)$ in the forms given above where the four y 's are linearly dependent solutions of (2) is that the determinant of M vanish, since then, and only then, is the rank of M equal to three. The value of the determinant of the matrix M being $\frac{1}{2}[P_5(u_1, u_2) \pm \sqrt{P_5(u_1, u_1)P_5(u_2, u_2)}]$, we have:

Theorem 3. The necessary and sufficient condition that two linearly independent solutions of (1), $u_1(x)$ and $u_2(x)$, should have associated with them four linearly dependent solutions of (2), $y_1(x)$, $y_2(x)$, $y_3(x)$ and $y_4(x)$, such that $u_1(x) \equiv y_1(x)y_2'(x) - y_1'(x)y_2(x)$ and $u_2(x) \equiv y_3(x)y_4'(x) - y_3'(x)y_4(x)$, is that

$$P_5^2(u_1, u_2) \geq 0, \quad n=1, 2.$$

and

$$P_5^2(u_1, u_2) - P_5(u_1, u_1)P_5(u_2, u_2) = 0.$$

Evaluating $Q(u_1, u_2)$ where $u_1(x)$ and $u_2(x)$ are two linearly independent solutions of (1) which satisfy the conditions given in Theorem 2, we find that

$$\begin{aligned} &\text{if } P_5^2(u_1, u_2) - P_5(u_1, u_1)P_5(u_2, u_2) \neq 0 \text{ then} \\ &Q(u_1, u_2) = -y_1(y_2, y_3', y_4'') + y_2(y_1, y_3', y_4''), \end{aligned}$$

where the parentheses represent three rowed wronskians which are solutions of our self-adjoint equation (2). If, on the other hand, $P_5^2(u_1, u_2) - P_5(u_1, u_1) \times P_5(u_2, u_2) = 0$, then by the preceding theorem our u 's are associated with four linearly dependent solutions of (2). The linear relation connecting them may be written

$$\begin{vmatrix} y_1(x) & y_2(x) & y_3(x) & y_4(x) \\ y_1'(\xi) & y_2'(\xi) & y_3'(\xi) & y_4'(\xi) \\ y_1''(\xi) & y_2''(\xi) & y_3''(\xi) & y_4''(\xi) \\ y_1'''(\xi) & y_2'''(\xi) & y_3'''(\xi) & y_4'''(\xi) \end{vmatrix} = 0$$

where at least one of the three rowed minors in the last three rows is different from zero. The first member of this identity is a solution of (2) whose value at $x=\xi$ is zero being the wronskian of our four linearly dependent y 's, and whose first three derivatives vanish identically at $x=\xi$. If, for definiteness, we let $(y_1', y_2'', y_3''')_{x=\xi} \neq 0$, then we have $(y_1', y_2'', y_3''')_{\xi} Q(u_1, u_2) \equiv (y_1(x), y_2'(x), y_3''(x)) [-y_1(x), (y_2', y_3'', y_4''')_{\xi} + y_2(x) (y_1', y_2'', y_4''')_{\xi}]$.

These evaluations of $Q(u_1, u_2)$ may be used in applying Theorem 1.

THE UNIVERSITY HEATING PLANT*

JOHN B. GRUMBEIN

The heating of the buildings on the University Campus was a comparatively easy matter as long as natural gas was cheap and plentiful, and prior to 1907 each building was independently heated by steam furnished by a fire tube boiler of proper size and attended by the janitor of the building.

With his usual keen vision Prof. F. L. Emory foresaw the growth of the University, and also the certain rise in the cost of gas together with possible shortages and in 1907 erected the central heating plant, and constructed a steam heating tunnel some 900 feet long, while certain buildings were reached with lines laid in Wycoff or terra cotta covering.

The first boilers installed were two 220 horse power Heines built for 150 pounds working pressure. These boilers were gas fired until the fall of 1918 at which time coal was substituted for gas and with the advent of coal and hand firing came the eternal smoke nuisance. The hand firing was not a success, due, of course, to the fact that it was impossible to secure competent firemen and in 1919 when two more boilers of the same size and type as those previously mentioned were installed, the firing problem with the accompanying smoke increase became still more difficult to handle and in 1921 the purchase of stockers was authorized by the President of the University and the State Board of Control.

The selection of the most suitable stoker presented several difficulties since it was considered advisable to install the underfeed type, provided one, which required a minimum of excavation, could be found. The floor of the boiler room being on solid rock with a water carrying strata just a few feet below emphasized the need for securing some type of stoker which required very little depth below the boiler room floor.

Various types, both overfeed and underfeed, were inspected and the final decision rested with the Type "E" stoker manufactured by the Combustion Engineering Company. Al-

though these stokers have now been in operation five full heating seasons not one has ever been shut down for the purpose of making repairs. Their operation has been highly satisfactory and the smoke entirely eliminated, except during cleaning periods.

With the four boilers, stoker fired, it was generally considered that the boiler problem was solved for at least ten years, and there was still room available in the building for the erection of two more of the same capacity as the others. At rating these six boilers would have handled a heating load of about 132,000 square feet of radiation. Three of the boilers running at about 125 per cent rating were capable of handling the load which was about 70,000 square feet.

A year later, however, the chemistry building contract was let and the surprising total of 76,000 square feet of equivalent radiation was to be added upon the completion of the building.

This fact stressed the need of a larger building in the very near future, or the purchase of a larger unit for the vacant space.

The latter idea was developed and during the summer of 1925 one 681 horse power, 200 pound B & W cross-drum boiler with a 50° Foster superheater was installed such that eventually, after the older boilers were ready to be junked, three more of the large capacity could be housed. At rating, the four boilers will carry a heating load of 272,400 square feet while the entire campus, including the chemistry building at present is about 142,000 square feet. This difference of 130,000 square feet seemed very small and the new boiler was accordingly equipped with a Taylor Stoker suitable to operate continuously at 200 per cent rating, and for two hours at 300 per cent. It can be seen therefore that with four of the large boilers in operation at 200 per cent rating a heating load of 544,800 square feet may be carried. As compared to the present load of 142,000 square feet it would appear

that the boiler problem can easily be taken care of as the needs require, with no change in the building itself for probably fifty years.

The decision to install a superheater was made only after a careful study of the performance of superheated steam in general. It is well known that superheated steam brings about most desirable benefits when used in turbines and engines due to the delay in reaching the temperature of saturated steam with the usual ill effects due to the presence of condensate. Certain power steam lines are today carrying superheated steam for long distances, and it is evident that in heating lines the same advantages may be expected as with power transmission lines.

The original line in the tunnel was 5-inch standard pipe and has probably never carried over 50 pounds pressure. The reasons being that when the boilers were gas fired a higher pressure was not possible and in the last few years consideration for safety required that the pressure be kept low.

In 1918 the steam lines were extended from a point in front of Commencement Hall to Oglebay Hall. In this case the sidewalk formed the roof of the tunnel, which housed 8-inch steam and 4-inch return lines.

The 4-inch line from Oglebay Hall to the Woman's Dormitory was laid in Wycoff covering and will probably require renewal in a few years. The combined length of these lines is about 600 feet.

Corrugated copper expansion joints were used in the 8-inch and 4-inch lines and these were guaranteed for 100 pounds pressure and 3-inch expansion. During the first year several of these joints failed and the replacements were furnished by the manufacturer but after several successive failures this type of expansion joint was entirely eliminated in favor of the sleeve type. It might be well to add that the joints were placed so that each joint was called upon to compensate for only one half the guaranteed expansion and the pressure was never in excess of 50 pounds.

Two other main lines, one from the old tunnel to the President's House and the Law School and the other from Commencement Hall to the Library, Mechanical Hall, and Armory are laid in Wycoff covering. From the latter line a 5-inch supply was just recently laid to serve the Chemistry Building temporarily.

With the exception of the lines under the sidewalk from Commencement Hall to Oglebay Hall all the pipes are old and too small for the service expected and it is now proposed to construct a new tunnel and locate it to better advantage with respect to the returns from the buildings situated on the lower elevations of the campus, and also to make possible the elimination of certain old troublesome lines and to make use of others for exhaust steam when it becomes feasible for the University to operate its own generating plant.

The new tunnel is to be of reinforced concrete 6 feet and 6 inches by 6 feet and 6 inches inside and wherever possible to make the roof serve as the sidewalk. There must of necessity be some heat loss from steam lines although they are properly covered, and by placing such lines, as are possible, directly under the walks the heat loss is put to good use and is much more efficient and faithful than the man with a snow shovel.

It is proposed to use all extra heavy pipe, extra heavy fittings, and Vanstone flanges. The extra heavy pipe is proposed not for the purpose of withstanding pressure alone but for the longer life due to the extra thickness of metal. Experience having proven that the distilled water rather quickly cuts a groove in the bottom of the pipe. Welded pipe offers some advantages over flanged pipe but on account of the anticipated difficulty in making repairs, due to the fact that experienced pipe welders are not usually available in the small towns, it does not seem feasible to resort to welding. Vanstone flanges, while probably more expensive than welded joints and also requiring gaskets appear to offer the best solution to the problem.

The new lines are to be 12-inch steam and 6-inch return with anchors drilled and arranged for duplication at a later time.

Pipe bends will be used to compensate for expansion, at such points where excavation and concrete work will not impose serious difficulties. At such places it is proposed to use Ross extra heavy cross-head guided steel expansion joints with bronze sleeves.

The first 12-inch line is to be suspended from "I" beams in the tunnel roof and the 6-inch line just below. When the load requirements increase, another 12-inch and 6-inch line will be suspended directly below the first.

With the two 12-inch lines the heating load can probably be carried for fifty years or more and only a very decided change in the direction, of campus growth will make it necessary to add any long extensions to the tunnel.

The University at present buys electric current for the simple reason that it is cheaper than to operate a generating station but it now seems that in a few years it will be economical because of steam requirements for the entire twelve months. When this time comes, the present old tunnel will carry only exhaust steam furnishing heat to those buildings nearest to the boiler plant, with proper provision for the admission of steam from the high pressure lines in case of shortage in the exhaust supply.

*Read at the Spring Meeting of the West Virginia Branch of the American Society of Mechanical Engineers held in Charleston, April 19, 1926.

DR. GEORGE RICHARD LYMAN

Dr. George Richard Lyman, Dean of the College of Agriculture of the West Virginia University since September 1, 1923, died at Johns Hopkins Hospital, Baltimore, Maryland, on June 7, 1926, after a prolonged illness.

Dr. Lyman was born at Lee Center, Illinois, December 1, 1871. He graduated from Beloit College, Wisconsin, in 1894, receiving an A. B. degree, from there he went to Harvard where he was granted an A. B. degree in 1897, A. M. degree in 1899, and a Ph. D. degree in 1906 with special training in Plant Pathology. He was an instructor in botany in 1901 to 1904 and an assistant professor in 1904-15 at Dartmouth College. In 1916 he was appointed pathologist in charge of plant disease survey for the U. S. Department of Agriculture which position he held until he came to West Virginia as Dean of the College of Agriculture.

He was a member of the war emergency board of American Plant Pathologists in 1918, Chairman of the advisory board 1919-21, and a member of the National Research Council 1919-22. He was the author of various articles and reports on mycology and plant disease.

He belonged to a number of honorary, professional, and social organizations among which may be mentioned the American Association for the Advancement of Science, American Academy of Arts and Sciences, Botanical Society of America, American Phytopathology Society of which he was secretary-treasurer, 1919-22, and president 1923, American Society of Naturalists, Botanical Society of Washington, Washington Academy of Sciences, Alpha Zeta, Phi Beta Kappa, Beta Theta Pi, Cosmos Club, and Kiwanis Club.

He was married to Frances E. Badger of Amboy, Illinois, June 23, 1903. He is survived by his wife who is matron of the Phi Beta Sorority, his daughter Mavis, who is a sophomore in the University, and his parents who reside in California.

Dr. Lyman came to the University four years ago. The College of Agriculture had been without a dean for a year, but it was not long, due to his tact, foresight, and ability, until he made a distinct and favorable impression. In his quiet, easy way he smoothed out difficulties and developed a spirit of cooperation upon the part of the staff and students. He began to develop forward looking policies which culminated in a plan for an agricultural educational development along very broad lines.

He entered into the life of the students more as a friend and advisor than as Dean of the College. Students were encouraged to frequent his office and no matter how busy he might have been the student's interests received his first attention.

In Dr. Lyman's passing the world has lost a scientist, the state has lost an agricultural leader whose work was only started, and West Virginia University and the College of Agriculture has lost one of its leaders. The place he filled in the minds and hearts of a host of friends will remain vacant.

—HENRY G. KNIGHT.

SAMUEL BOARDMAN BROWN

Professor Samuel Boardman Brown was stricken down by cerebral hemorrhage on the afternoon of September 18, 1926. His death came as a great shock to fellow faculty members and the community at large, as he had been in apparently good health. At the time of his decease he was the oldest in active service, of professional rank, on the West Virginia University Faculty.

He was born March 5, 1860, in Preston County, West Virginia, a son of Granville and Elizabeth (Watson) Brown. Following attendance at the local schools, he went to West Virginia University, receiving the Bachelor of Arts degree in 1883 and the degree of Master of Arts in 1886. Some time was spent in graduate work at Washington, D. C., and at Harvard. For two years he was in charge of a private school at Martinsburg, West Virginia. In 1885 he was elected Principal of the Glenville State Normal School. In 1890 he was made assistant in Geology at West Virginia University. From this position he was advanced to Professor of Geology, 1892, with charge of the Department, a position held to the time of his death.

He was married June 17, 1890, to Miss Luella Butcher, who preceded him in death by three years. Three daughters and one son survive.

A large part of the geological equipment of West Virginia University, as well as a number of mounted animals, belonged to him personally. Much of this equipment was included in the departmental inventory, thus indicating his desire that it be held by the University. His family has kindly turned the collection over to the University as a Memorial, and has agreed that the mounted specimens be given to the Zoological Department.

Professor Brown was one of the committee on the organization of the West Virginia University Scientific Society, and was the second president of this Association, 1915-16. He

held membership in the American Association for the Advancement of Science, the Monongalia Historical Society, and other organizations. He refused at least one distinction generally much coveted.

He contributed many articles to scientific and other publications, usually along the line of Economic Geology. He was the author of Bulletin Number 1 of the State Geological Survey.

Always unostentatious, highly democratic, few of his colleagues realized his contribution to scientific work. He was one of the earliest and most vigorous advocates of a State Geological Survey against powerful opposition. Much of this antagonism later vanished, and a Geological Survey was built up, which ranks, by its reports, with the foremost surveys of the country.

—EARL R. SCHEFFEL.

BULLETIN OF THE WEST VIRGINIA UNIVERSITY SCIENTIFIC ASSOCIATION

VOL. 2
NO. 3



OCTOBER 15
1928

CONTENTS

	Page
Officers, past and present, of West Virginia University Scientific Society	2
Members of State Board of Control and Board of Governors	3
Program of West Virginia University Scientific Society, 1927-28...	4
Modern Physics and Its Applications; R. C. Colwell	5
History of the Development of the Department of Geology, at West Virginia University; J. L. Tilton	11
The Northern West Virginia Section of the American Chemical Society—Historical Sketch; E. C. H. Davies	20
Determination of the Fineness of Marl and Ground Limestone; E. P. Deatrick and C. Dorman	26
Tastes and Odors in Water Supplies with Special Reference to Waste Liquors from By-Product Coke Plants; W. W. Hodge	30
Factors Affecting Fruit Setting in the Apple; H. E. Knowlton	46
The Inheritance of a Quantitative Character, Length of Rachilla, in an Oat; T. E. Odland	57
Geology from Morgantown to Cascade, West Virginia, Along State Route Number 7; J. L. Tilton	65
Abstract of Recent Papers by Members of the Science Faculties of West Virginia University	87

OFFICERS OF THE WEST VIRGINIA UNIVERSITY SCIENTIFIC ASSOCIATION

PAST PRESIDENTS

A. R. Whitehill	1914-15
S. B. Brown	1915-16
F. E. Emory	1916-17
C. W. Waggoner	1917-18
B. H. Hite	1918-19
A. M. Reese	1919-20
Aaron Arkin	1920-21
N. J. Giddings	1921-22
R. P. Davis	1922-23
G. S. Dodds	1923-24
G. R. Bancroft	1924-25
G. H. Gill	1925-26
E. R. Scheffel	1926-27
R. J. Garber	1927-28

OFFICERS FOR 1928-29

President	F. A. Molby
Vice-President	W. W. Hodge
Secretary	E. P. Deatrick
Treasurer	R. C. Colwell

PROGRAMME COMMITTEE

E. P. Deatrick,
R. B. Dustman
P. D. Strausbaugh
J. L. Tilton

PUBLICATION COMMITTEE

G. S. Dodds
N. J. Giddings
C. A. Jacobson
C. E. Lawall
A. M. Reese, Chairman

Science library
Exch.
W. Virg. Univ.
Library
7-18-39

WEST VIRGINIA UNIVERSITY

MORGANTOWN

Established February 7, 1867

THE STATE BOARD OF CONTROL

	TERM EXPIRES
JAMES S. LAKIN, PRESIDENT, <i>Charleston</i>	June 30, 1933
C. A. JACKSON, <i>Charleston</i>	June 30, 1929
F. W. McCULLOUGH, TREASURER, <i>Charleston</i>	June 30, 1932

The State Board of Control has the direction of the financial and business affairs of the state educational institutions.

THE BOARD OF GOVERNORS

	TERM EXPIRES
EDWARD GRANDISON SMITH, PRESIDENT, <i>Clarksburg</i>	June 1, 1930
DAVID ALLAN BURT, VICE PRESIDENT, <i>Wheeling</i>	June 1, 1930
FRANK HENNER BABB, <i>Keyser</i>	June 1, 1932
HUGH IKE SHOTT, JR., <i>Bluefield</i>	June 1, 1929
GERTRUDE ROBERTS, <i>Huntington</i>	June 1, 1929
ARTHUR BURKE KOONTZ, <i>Charleston</i>	June 1, 1932
ROBERT LINCOLN RAMSAY, <i>Wellsburg</i>	June 1, 1929
CHARLES THOMPSON NEFF, JR., SECRETARY, <i>Morgantown</i> .	

The Board of Governors has charge of the educational and administrative affairs of the University.

THE WEST VIRGINIA UNIVERSITY SCIENTIFIC
SOCIETY HELD THE FOLLOWING MEETINGS . .
DURING THE YEAR 1927-28

- October 28, 1927 Mr. H. C. Kneeland
 "The Design and Operation of a Four Million Gallon
 Zeolite Water Softener."
 Mr. John M. Rice
 "Water Purification and the Proposed Modern Fil-
 tration Plant for Grafton, West Virginia."
 Mr. E. S. Tisdale
 "Recent Work in Water Purification in West Vir-
 ginia."
 This was a joint meeting with the West Virginia
 Association of Water Works Superintendents and
 Filter Plant Operators.
- November 18, 1927 Prof. G. P. Boomsalter
 "Telemeter Tests of a Hoisting Cable at the Ida May
 Mine."
- December 2, 1927 Dr. David White
 "Geological Antiquity of Some of Our Trees and
 Plants."
 A joint meeting with the University Sigma Xi Club.
- January 27, 1928 Dr. Holly E. Cunningham
 "Relations Between Science and Philosophy"
- February 23, 1928 Dr. Arthur H. Compton
 "What Things Are Made Of."
 A joint meeting with the University Sigma Xi Club.
- March 30, 1928 Dr. P. D. Strausbaugh
 "Botanizing in West Virginia"
- April 27, 1928 The Scientific Society members were invited to at-
 tend the formal meeting for the year of the Sigma
 Xi Club. Dr. C. A. Shull was the speaker of the
 evening.
- May 25, 1928 Dr. Charles A. Shull
 "The Life and Work of Stephen Hales."
 At this meeting officers for the year 1928-29 were
 elected.

MODERN PHYSICS AND ITS APPLICATION

R. C. COLWELL

Professor of Physics, West Virginia University

The early part of the nineteenth century saw the beginning of modern electrical theory. Faraday by his researches on electro-magnetic induction laid the foundations for the invention of the electric dynamo, the motor, the telegraph, the telephone and the incandescent light. In 1865, Maxwell advanced his electro-magnetic theory of light and in the early eighties Hertz in Germany produced ether vibrations of various wave lengths which were destined later to be known as Hertzian or Wireless Waves.

By the year 1890, most physicists felt that all the major foundational laws of nature had been discovered and that it remained for physicists to extend these laws rather than to discover new ones. They were in much the same category as the clerk who resigned from the United States Patent office in 1830 because he thought that everything which could be invented had been invented. The astounding discovery of X-rays or Roentgen rays in 1895, opened a new field of investigation to physicists and prepared the way for many new theories of nature as well as giving us many practical applications. The X-ray tube consists of a highly evacuated glass bulb with a metal electrode inserted at each end. When an electric discharge at high voltage is passed through this tube rays are developed which will pass through objects such as wood, aluminum, steel, and flesh. Professor J. J. Thomson investigated these tubes and showed that there exists in nature a much smaller particle of matter than the hydrogen atom. Nineteenth century chemistry taught that there were ninety-two distinct atoms in nature and that these were unchangeable and immutable—the smallest of these was the hydrogen atom. Twentieth century physics states that the electron is only one two-thousandth of the hydrogen atom and is always associated with a negative charge of electricity. The electrons in the

X-ray tube move with very great rapidity, about 100,000 miles per second; when they strike the metallic conductor in the tube, they set the atoms in vibration in such a way as to give very short wave vibrations. Now ordinary visible light consists of vibrations in the ether—about twenty-five thousand to the inch, but X-rays are so short that we could place twenty-five million of them to the inch. Wireless waves come at the other end of the scale and they vary in length from 3 feet to 12 miles.

The X-rays are widely applied by physicians in locating foreign particles in the body, in setting broken limbs, in determining the condition of the teeth and in the treatment of some forms of skin diseases. X-rays have the property of disintegrating skin tissue, causing severe burns so that all X-ray tubes must be handled with considerable circumspection.

As soon as X-rays were discovered, physicists were interested in finding out if there were any substances in nature which would give out penetrating rays similar to these. Becquerel found that uranium had this property and shortly afterward Madame and Monsieur Curie isolated the element radium which gives out three kinds of rays designated as α (alpha), β (beta), and γ (gamma) rays. The alpha rays when examined turned out to be positively charged atoms of helium. The beta rays are streams of electrons similar to the electron stream in the X-ray tube while the gamma rays are very penetrating or hard X-rays. On account of the disintegrating action of these hard rays, radium also is useful in the destruction of surface cancers, tumors, and so forth. The radium is kept in a thick container of lead to prevent the gamma rays from burning the person who carries it around.

Radium is also of interest in the realm of pure physics because the alpha particles are really helium atoms. Thus one element, radium, is spontaneously generating another element, helium. As a matter of fact, radium eventually degenerates into the element lead. Thus the dream of the

alchemists that one element could be transmuted into another is being realized before our eyes in a tube containing radium. So far, however, no scientist has succeeded in changing one element into another—the process goes on in nature but not in the laboratory.

In the early years of the twentieth century, a young Englishman, Richardson by name, showed that heated metals give out streams of negative electrons. This phenomenon had actually been investigated by Edison back in 1880 but he was unable at that time to give a scientific explanation of his results. If a metal wire is placed in a vacuum tube and the wire heated the tube will be filled with a cloud of negative electrons. If another electrode called the plate is placed in the tube and positively charged, a current of electrons will flow from the wire filament to the plate. Now the negative electrons will flow in one direction only—hence such a tube will act like a valve in that electric current can pass through it only from the plate to the filament and never from the filament to the plate. These tubes, now called diodes, were invented by Fleming and are used in many kinds of rectifiers for charging up a storage battery from an alternating current circuit. They are also the main part of all kinds of A and B battery eliminators.

In 1907, DeForest put an additional electrode in the diode, which he called a grid, and the diode was thus transformed into a triode or three electrode tube. These triodes are of course the basis of all the sending and receiving sets in wireless telephony and telegraphy. The triode is the greatest electrical invention of the twentieth century. The chief virtue of the triode is that it will produce wireless oscillations, receive them and also amplify them without any distortion whatsoever. The triodes were first used for booster circuits in land telephony. Only a few years ago it was impossible to telephone farther than from New York to Chicago. With the advent of the triode, the voice currents on the telephone lines may be amplified millions of times so that telephony from

New York to San Francisco is now a matter of daily routine in the offices of the American Bell Telephone Company.

Large triode tubes of about fifteen kilowatt or twenty horse power are now used to generate the carrier waves in the broadcasting stations. About five years ago the filament was made of the metal tungsten and required one ampere of current to release a sufficient supply of electrons. The newer filaments are impregnated with thorium oxide and only one-fourth of an ampere is necessary for these tubes. The vacuum must be very high and this high vacuum is obtained by pumping with a Langmuir mercury pump and then exploding a ribbon of magnesium inside the tube. The vaporized magnesium condenses on the inner surface of the tube giving it its characteristic mirror-like appearance.

The investigation of electron streams from hot bodies has also lead to a very great improvement in the X-ray tubes. The early tubes were not highly evacuated. The residual gas became ionized under the discharge, the tube glowed with a greenish glow and its action was somewhat uncertain. The Coolidge tube is so highly evacuated that a little wire inside it must be heated to give a supply of negative electrons for producing the X-rays. On account of its high vacuum, the Coolidge tube is very regular in its action and much more reliable than the older tubes.

Since the mass of the electrons is very small, the inertia of an electron stream is practically negligible hence a vacuum tube with a stream of electrons in it may be acted upon by any kind of a magnetic or electric field. In the usual arrangement, the electron stream falls upon a plate which flouresces under the impact of the electron stream. Such an instrument is called an oscillograph and is useful in determining the wave form of any kind of an alternating current. It has also been used to determine the nature of the disturbances called static which interfere so much with radio reception. Static is due to electric discharges in the air, much of it comes from thunderstorms at great distances away. The oscillograph may also

be arranged with a wireless receiving apparatus so as to show automatically the direction of any sending station. A station received on one loop will make the spot in the oscillograph vibrate up and down in a straight line but if two loops are used, the straight line will be rotated through a certain angle and this will give the direction of the sending station.

The development of wireless telephony has also lead to a very great increase in our knowledge of sound and its mechanical reproduction and therefore to an improvement in phonographs and loud speakers. The triode itself is so perfect an instrument that no distortion of the electric current need take place on it but when the electric current is eventually transformed into a sound wave and transmitted through a horn the horn itself will usually either add to or subtract from the original vibrations giving either a change in the quality of the music or extraneous undesirable noises. It has been found during the last few years that horns of special shape and material will not distort the sound waves. In some cases a cone diaphragm is used instead of a horn. The theory of wireless reproduction has also been applied to phonographs. The sound waves of the music are first transformed into electric waves and these are amplified before they act upon the recording disk. In this way the new orthophonic records are produced and in them the correct tone value and volume is given to each instrument or voice which is recorded.

The early experiments in wireless telegraphy seemed to indicate that long waves travelled around the earth better than short ones. For this reason waves from three hundred to twenty thousand meters, or from one-fifth of a mile to ten miles long were used until 1920. Then Marconi investigated short waves from twenty to one hundred meters (sixty to three hundred feet) and found that under certain conditions these short waves could be heard thousands of miles away. Enormous power was required to generate the long waves but the short waves are just as useful with only one one-hundredth of the power. In a very little time short waves will be used

for trans-oceanic communication. They not only have the advantage noted above but they can also be reflected into a narrow beam about eighteen degrees across, thus most of the energy goes in one direction and is not scattered to the four corners of the earth as in the case of long waves. Within the last two months a short wave beam system has been working between Great Britain and Canada.

A short wave beam system or Radio lighthouse is in use along the coast of Scotland. When a mariner is in a heavy fog he can still determine his direction from the radio beam. The whole reflector rotates and a definite signal is sent out for every point of the compass. For instance when the radio beam is north it sends out, let us say, the letter A and fifty degrees east of north it sends out the letter B, and so on. Hence the sea captain will know his direction from the lighthouse by the letter received.

During this winter (1927-28) Mr. I. O. Myers, an instructor in our laboratory, has been in telegraphic communication with other stations in Texas, Oklahoma, New York, Iowa and Missouri. We are using a short wave set of forty meters with an oscillating triode of only seven watts power input.

HISTORY OF THE DEVELOPMENT OF THE DEPARTMENT OF GEOLOGY AT WEST VIRGINIA UNIVERSITY

JOHN L. TILTON

Professor of Geology, West Virginia University

It was on the 18th of September, 1926, that Samuel B. Brown, Professor of Geology, was so suddenly removed from our midst. In the re-arrangement that followed it became necessary to sort out his private books and papers and to transfer the property of the department from its old quarters in Mechanical Hall to its new quarters at the north end of the first and second floors of the new Chemistry Building. Through the combined efforts of Mr. Samuel Brown, Jr., and myself the sorting out of the private property was soon accomplished, and the private papers and books removed. With the consent of the family the mounted specimens of birds and mammals, perhaps twenty or so, were transferred to the Department of Zoology for display there. Other things, such as antlers were retained in the geological collections. At the time of the transfer and repeatedly since that time the question has arisen, where were the various collections obtained that are now at the university? There were no records in the department that answered this question. It was with a view to answering this question that the various catalogues were consulted and information sought especially of Dr. I. C. White. Along with data concerning the collections, other information was obtained that proved of much interest to the writer, and of importance to anyone who may seek to learn the history of development of this portion of the university.

THE PERSONNEL

Of necessity the beginnings were very modest. The Reverend Alexander Martin, D. D., who was elected President of the prospective university in April, 1867, was inaugurated June 27, 1867. In the first catalogue published, that of

1867-8, Samuel G. Stevens was listed as Professor of Natural Sciences, a department in which a course in geology and another in mineralogy were offered in the junior year. The entire equipment of the scientific department at that time amounted to \$304.27. Professor Stevens continued Professor of the Natural Sciences till 1869, at which time he was relieved of the geological portion of his work by John J. Stevenson, who was Professor of Geology from 1869 to Christmas, 1871, at which time he became Professor of Geology at The University of the City of New York, Professor Stevens completing the year for him here at the university. William M. Fontaine followed, who was Professor of Geology from 1872 to 1879, at which time he resigned to become Professor of Geology at The University of Virginia. During his last two years at Morgantown I. C. White was associated with him. On Fontaine's resignation Dr. White became the Professor of Geology and remained in that capacity till 1892.

The name of Samuel B. Brown first appears in the catalogue of 1890-1891, along with Dr. White. He is listed as Assistant in Geology till 1893. In the 1893-4 catalogue Professor Brown is listed as Professor of Biology. In the next catalogue he is listed as the Professor of Geology, a position which he held till the time of his death. In the year 1897-8 there was evidently a student assistant in the department whose name is not given. Apparently the next year Professor Brown taught alone, but from 1901 to 1903 a Mr. Witham was mentioned with Professor Brown as giving instruction in the department, Mr. Witham also serving in the Department of Physics. During 1906-1909 Professor George P. Grimsley was associated with Professor Brown as Special Lecturer in Economic Geology, and Mr. Clarence Post of the Department of Physics was listed as the teacher of Meteorology. From 1909 to 1913 Professor Brown taught without assistance. In 1913 W. Armstrong Price, Jr., became Assistant Professor of Geology. Dr. Price planned to close his work for the university in June, 1918, but Mr. M. L. Nebel, who was elected to succeed him, died before he could begin work. Dr. Price

completed the year, thus closing his work at the university in June, 1919. In the fall of that year Dr. Price was succeeded by Earl R. Scheffel, who closed his work in June, 1927. In the fall of 1920 John L. Tilton began his work at the university, and in the fall of 1925 Walter J. Yeaton began his work, both of whom are still on duty at the university. Professor Brown's successor was not secured till the middle of the year, Sidney L. Galpin appearing for duty February 8, 1927. During the week beginning with November 25, 1927, the department is further strengthened by the presence of Dr. David White of Washington, D. C., who is serving this year as a Special Lecturer on Palaeobotany.

EARLY REPORTS

Scientific papers are included in the appendices to the catalogues, as reports to the Board of Regents. The catalogue of 1869-1870 contains the early report of J. J. Stevenson on "A Geological Examination of Monongalia County, West Virginia" (pages 42-73) including Meek's report on the fossils which Stevenson had collected at "The Hogback" just east of Morgantown and sent to him for identification.

It is well to notice that as far back as June 18, 1873, President Martin urged the organization of a Natural History Survey (p. 60 of the 1873-74 catalogue), a far-sighted plan which obtained fruition in 1897 at the organization of the present West Virginia Geological Survey.

In the appendix to the catalogue of 1882-3, pages 48-68, is Dr. White's first article on "Notes on the Geology of West Virginia." Other articles under the same general head appear on pages 63-94 of the 1883-4 catalogue and on pages 45-81 of the 1884-5 catalogue. These articles also appeared in "The Virginias."

THE CURRICULUM

The first instruction, that of Samuel J. Stevens, was in mineralogy. This remained the only subject taught till 1877,

when Dr. I. C. White began his work at the university. At that time classes in what is strictly geology were organized. In the 1881-82 catalogue (p. 58) arrangements for a month's field trip with Dr. White are mentioned for the spring vacation, a plan that was followed in the remaining years of Dr. White's services as the Professor of Geology at the university. The plan was continued at first by Professor Brown, but after 1893-4 there is no further reference to extended trips in the spring recess. It was, however, Professor Brown's plan to give instruction in the field to all his beginning classes, a plan enthusiastically followed by his associates in the department. This was independent of advanced courses in geological field work that appeared in 1919 and later as additional help was obtained. Summer field work was re-introduced by John L. Tilton in 1925. In the 1926 catalogue summer field work and travel courses are inaugurated and accepted by Professor Brown, but up to the present they are essentially undeveloped.

During the time that Professor Brown was alone in the department he taught classes in General Geology, Historical Geology, Economic Geology, Mineralogy and Building-stones. When W. Armstrong Price came in 1913 he relieved Professor Brown of Historical Geology and the Geology of Non-Metals, and the following year offered a course in Methods in Palaeontology, Professor Brown adding a course in the Geology of West Virginia and one on the History of Geology. W. Armstrong Price later added courses in Oil and Gas Geology, and field courses in geology. When he closed his work in 1919 Earl R. Scheffel continued the subjects except the Palaeontology though with somewhat of change in numbers. The following year he released the Historical Geology to John L. Tilton, who began work at that time, and added a course in Physical Geography. These courses he continued with somewhat of expansion till the close of his work in 1927. Tilton offered courses in Palaeontology, including Stratigraphic Palaeontology, and added a systematic course in the Microscopic Study of Minerals and Rocks. The latter he transferred to Walter J. Yeaton, who also took one of Professor

Brown's courses in Mineralogy. Sidney L. Galpin later took Professor Brown's other class in Mineralogy, the Economic Geology of Non-Metals and Building Materials. Thus at the present time the Department is organized approximately as follows: Historical Geology and Palaeontology, Tilton; Mineralogy, Petrography and Metals, Yeaton; and Non-Metals and Building Materials, Galpin, with all assisting in the General Geology. Geography is at present not provided for, and further adjustment awaits the action of Professor Galpin.

LOCATION

Up to 1911 the work of the Department of Geology was conducted in the northwest corner of the basement of Martin Hall. When in the college year 1910-1911 a re-assignment of rooms was made at the opening of the north wing of Woodburn Hall, the Department of Geology was moved to Science Hall where it occupied rooms 30 and 31 to the close of the college year 1912-13, following which the Department was moved to rooms 20 and 21 of the Library Building, on the same floor as the rooms occupied by the State Geological Survey. Here it remained through the college year 1917-1918, following which it was moved to rooms 111, 112 and 113, Mechanical Hall. In September, 1926, the Department was again moved to rooms 102, 128 and 201 of the new Chemistry Hall.

THE COLLECTIONS

The collections which Professor Stevens listed in 1867-8 as valued at \$304.27 were especially for Physics, but the outfit included 114 minerals for use by the class in Mineralogy. In 1870 Stevenson reports the presence of a collection of 700 fossils and gives the list of names (page 82-87).

The catalogue that first mentions Fontaine as Professor of Geology (1872-3, page 38) mentions the presence of 2000 specimens of minerals and fossils and more than 2300 recent shells. This statement was repeated in the succeeding catalogues, appearing last in the catalogue of 1885-6 (page 67).

In the catalogue of 1887-8, page 43, mention is made of the donation by Professors I. C. White and Wm. M. Fontaine of a collection of fossil plants upon which they had been at work together. These are reported upon in the volume PP of the Second Geological Survey of Pennsylvania: "The Permian or Upper Carboniferous Flora of West Virginia," by Wm. M. Fontaine and I. C. White, 1880. In an endeavor to ascertain what had become of this valuable collection an inquiry was addressed to Professor Wilbur A. Nelson at University, Va. He replies, "I regret to say that Fontaine's collection of coal plants was practically destroyed by a fire that originated in this building several years ago and almost none are left."

The catalogue of 1885-6 (page 67), Dr. White, Professor of Geology, mentions the purchase of Henry A. Ward's College Collection of Rocks and Minerals. This valuable collection is still at the university and as serviceable as ever. The collection is mentioned repeatedly till 1893-4.

In the catalogue of 1893-4 (page 26) mention is made of the Julien Building Stones, and also of large additions from the World's Fair collections of economic geology. Apparently the latter are miscellaneous specimens now scattered through the Ward's collection of minerals. There is no special World's Fair set.

In the 1894-5 catalogue (page 32) is a print illustrating a number of maps and charts which apparently had then been recently obtained. Other illustrations are on page 40 of the 1895-6 catalogue and on page 54 of the 1896-7 catalogue. In the 1896-7 catalogue is the statement that Ward's College Collection of Palaeontology is very nearly complete. It thus appears that this collection, so indispensable to the consideration of past life, was obtained in the early years (1894-7) of Professor Brown's service as Professor of Geology.

The catalogue of 1898-9 (page 22) mentions the presence of many thousands of fossils, casts, models, building

stones, and Ward's collections. The inference is that in the preceding year, or thereabouts, Professor Brown had secured by gift the Educational Series of Rocks put out by the U. S. Geological Survey at that time, as described in Bulletin No. 150 (1898) of the U. S. Geological Survey, and that he had also received as a gift the collection of fossils sent out by the Smithsonian Institution. The building stones mentioned are not a set from West Virginia but a set of valuable polished hand specimens of choice rock from all over the world, presumably the Julien Collection. The above collections are still here, damaged somewhat by repeated moving, but still both ornamental and useful, awaiting only the advent of additional display cases and suitable space.

During these years, especially 1894-1899, there are in the catalogues repeated calls for local material suitable for a collection. Several donations are mentioned. Numerous arrowheads arrived that were packed away in boxes when the Department was located in Mechanical Hall, but are now visible again in the cases. It was during one of the summers in those years that Professor Brown when in the West secured the various Indian relics and antlers which are still in the collection of the Department.

Supplementing the above collections are the series of 125 hand specimens and microscopic slides of American Rocks, purchased in 1923, the collections of "Index Fossils" purchased in 1926 and 1927 from the National Museum at Washington. All of these were obtained on requisition of the writer with approval of Professor Brown, and the fine collection of microscopic slides of English "coal balls" purchased in 1925, a valuable set that is needed for instruction and reference. By another year it is hoped we shall have obtained a fairly complete series of plant fossils.*

*Other collections not belonging to the Department can be of use when needed. One is the zoological collection in Science Hall. A second collection is that at present held by the State Geological Survey, chiefly collections made by George P. Grimsley and David B. Reger. A third collection is that of rocks and minerals donated to the School of Engineering by Mr. Stuart M. Buck of Bramwell, West Va.

INVENTORIES AND ATTENDANCE

The first inventory was made in 1908, immediately before the State Board of Control took charge of the state institutions. Subsequent inventories were made in 1917, 1921, and 1925.

In Professor Brown's letter to Dr. D. B. Purinton, dated April 17, 1908, which serves as the first inventory, the total value of the equipment is listed at \$500. The classes registered are stated as follows:

General Geology	20
Economic Geology	17
First Class in Mineralogy	11
Second Class in Mineralogy	7
Total	55

In 1917 the totals are as follows:

Furniture	\$ 800
Apparatus	780
Machinery	40
Collections	2500
Books and Maps	750
Total	\$4870

The difference between these two inventories represents the value of collections added, and of the instruments purchased in part for the accommodation of W. Armstrong Price.

In 1921 the totals are as follows:

Apparatus	\$1050
Books and Maps	775
Furniture	810
Machinery	40
Collections	2076
Total	\$5351

In 1925 the totals are as follows:

Scientific Apparatus	\$2138
Collections	3176
Books and Maps	1020
Furniture	820
Machinery	50
Miscellaneous	300
Total	\$7504

Unfortunately this inventory of March 6, 1925, does not mention in detail all of the apparatus listed that had recently been obtained.

Another item of importance that does not appear in an inventory is the result of work upon the collections. When the writer appeared upon the scene (in 1920) he proceeded to put the collection of fossils into usable order, note gaps in the collection, and prepare for the proper cataloguing. The specimens obtained in recent years are now catalogued, and the work of cataloguing the older collections is proceeding as fast as needed help is obtainable. Information concerning a number of specimens secured in former years has been lost because no record was kept. Space for storage and for display is one of our needs, and we still await a Geological Building where what we have can be permanently located in a manner convenient for study; and where what is choice can be properly displayed for the benefit of the public. Give us a building for Geology suited to this wonderful geological field!

THE NORTHERN WEST VIRGINIA SECTION OF THE
AMERICAN CHEMICAL SOCIETY —
HISTORICAL SKETCH

EARL C. H. DAVIES

Associate Professor of Chemistry

The Northern West Virginia Section of the American Chemical Society, with headquarters at Morgantown, West Virginia, embraces the counties of Marion, Preston, Monongalia, Marshall, Wetzel, Harrison, Taylor, Barbour and Tucker, West Virginia. Until April of 1922 this territory had been under the jurisdiction of the Pittsburgh Section of the American Chemical Society.

In April, 1922, at Birmingham, Alabama, the Council of the National Society voted to grant a charter to the Northern West Virginia Section.

Charter members of this local section who are still members include: G. R. Bancroft, G. A. Bergy, F. E. Clark, A. R. Collett, W. F. Dalzell, E. C. H. Davies, W. W. Hodge, C. A. Jacobson, C. L. Lazzell, S. Morris, H. F. Rogers, and Lilly Belle Sefton Deatrick. There are at present about thirty-nine members, representing all the different varieties of chemistry taught on our campus and including teachers from other colleges and high schools and chemists who are definitely connected with the glass, coke, gas, coal, mining and the paper industries.

Since its origin in 1922, it has been the policy of the Northern West Virginia Section of the American Chemical Society, each year to bring to Morgantown, a limited number of chemists of national and international reputation. A brief summary of some of these lectures may be of interest. This list is not complete and does not include any of the excellent papers given by members of our own section. All these lectures have been open to the public and have been generously

attended by scientists of this section and by the members of the university and their friends. These lectures were attended by an average of perhaps one hundred. Following the lectures have been discussions and questions which have been highly stimulating to all who were present.

LECTURES¹ GIVEN AT WEST VIRGINIA UNIVERSITY UNDER THE
AUSPICES OF THE NORTHERN WEST VIRGINIA SECTION
OF THE AMERICAN CHEMICAL SOCIETY

1923—E. C. Franklin, Professor of Chemistry at Leland Stanford University and President of the American Chemical Society, March 27, 1923. Subject: "Ammonia as a Solvent." Lecture was illustrated by many samples and experiments and was given in Commencement Hall. Liquid ammonia dissolves chemicals in much the same way as does water. There is an ammonia system of acids, bases and salts corresponding to the water system of acids, bases and salts.

E. E. Slosson, Director of Science Service, Washington, D. C., and editor of a number of books, including "Creative Chemistry." Subject, "Creative Chemistry." Given in Commencement Hall, April 18, 1923.

1924—W. E. Henderson, Professor of Chemistry at Ohio State University at Columbus, Ohio, and co-author of the numerous McPherson and Henderson texts for high school and college chemistry. January 22, 1924. Subject: "Lost Arts in Science." Among the chemical achievements of olden times was the manufacture of a very good grade of cement. But it should be remembered that only the best has survived the ravages of time. Hundreds of poor batches were made and have disappeared. In modern times the products are more uniformly good. Science has replaced Art.

Neil E. Gordon, Professor of Chemistry at the University of Maryland, College Park, Md., editor of the Journal of Chemical Education and author of texts in general chemistry, November 7, 1924. Subject: "Correlation of High School and College

¹Lectures by members of the local section have been omitted.

Chemistry." This may be accomplished only by the cooperation of high school and college teachers—not by either group alone.

1925—L. A. Parsons, Professor of Physics at Gettysburg College, April 30, 1925. This lecture was given in Martin Hall and was illustrated by numerous colored slides of flowers, scenery and people. Subject: "Color Photography."

1926—Hugh S. Taylor, Professor of Chemistry at Princeton University, editor of text books and reference books on physical chemistry and editor and associate editor for several scientific publications, including *The Journal of Physical Chemistry*, March 25, 1926. Subject: "Contact Catalysis." A solid catalyst owes its power to a relatively few of its surface atoms. The activity is due to the outlying positions of these atoms resulting in unbalanced fields of force.

James F. Norris, Professor of Chemistry at the Massachusetts Institute of Technology, President of the American Chemical Society, editor of *International Chemical Series* and author of organic and inorganic chemistry texts, March 30, 1926. Subject: "Research—Past, Present and Future." One of the most promising fields of future research is the study of the action of electrons upon chemical composition.

Dr. Beal, Assistant Director of Mellon Institute, Pittsburgh, November 30, 1926. Subject: "How Mellon Institute Solves Practical Problems for Industry." One of the most interesting of these problems was the development of artificial sausage casings whose length may be inches or miles, just as desired.

1927—B. S. Hopkins, Professor of Chemistry at the University of Illinois, and the discoverer of illinium, April 9, 1927. Subject: "The Search for New Elements." (Of the ninety elements known, illinium is the only one discovered in America.)

A. C. Fieldner, Superintendent of the Pittsburgh Station

of the Bureau of Mines, May 9, 1927. Subject: "Recent Developments in Carbonization and Processing of Coal." The new Bergius process for hydrogenation of coal converts 1000 kilos of raw lignite coal into 490 kilos of coal oil, 210 kilos of gas, and 300 kilos of tar residue.

D. R. Kellogg, Director of Chemical Research at Westinghouse Electric and Manufacturing Company (Pittsburgh), October 26, 1927. Subject: "Some Aspects of Industrial Research."

1928—Frank C. Whitmore, Chairman of the Chemical Section of the National Research Council (Washington, D. C.). Professor of Chemistry at Northwestern University (Evanston, Illinois). Director of Colloid Symposium and Director of the Institute of Chemistry, January 18, 1928. Subject: "Habits of the Atoms" (in the evening). "Organic-Mercury Compounds" (in the afternoon). General Chemistry may well begin with the study of the electrical composition of atoms and compounds.

Harry N. Holmes, Professor of Chemistry at Oberlin College (Oberlin, Ohio). Editor of Colloid Symposium Monographs and author of a number of text books for general chemistry and for colloid chemistry, May 4, 1928. Subject: "Public Interest in Chemical Research" (in the evening). "Emulsoids" (in the afternoon).

Alexander Silverman, Chairman of the Chemistry Department of the University of Pittsburgh, November 14, 1928, in Chemistry Hall. Subject, "Glass" (in the evening), "Unsolved Problems in Glass Manufacture" (in the afternoon). The evening lecture was illustrated by many colored slides and samples.

S. W. Parr, of the University of Illinois, President of the American Chemical Society, inventor of the Parr calorimeter and other pieces of apparatus used in coal technic, November 27, 1928, in Chemistry Hall. Subject: "The Carbonization of Coal."

OFFICERS OF THE NORTHERN WEST VIRGINIA SECTION OF THE AMERICAN CHEMICAL SOCIETY

Year.	Chairman	Vice-Chairman	Secretary-Treasurer	Councilor
1922	F. E. Clark	W. W. Hodge	E. P. Deatrick	H. G. Knight
1923	F. E. Clark	W. W. Hodge	E. P. Deatrick	H. G. Knight (E. C. H. Davies)
1924	F. E. Clark	H. F. Rogers	I. W. Smithy (and Hubert Hill)	H. G. Knight (S. Morris)
1925	W. W. Hodge	J. G. Sweeney	Hubert Hill	F. E. Clark
1926	C. A. Jacobson	G. A. Bergy	S. Morris	W. W. Hodge (F. E. Clark)
1927	S. Morris	E. C. H. Davies	C. E. Garland	C. A. Jacobson (A. R. Collett)
1928	E. C. H. Davies	G. R. Bancroft	R. B. Dustman	S. Morris
1929	R. B. Dustman	E. F. Chase	A. R. Collett	E. C. H. Davies

PRESENT MEMBERS OF THE NORTHERN WEST VIRGINIA SECTION
OF THE AMERICAN CHEMICAL SOCIETY

- R. J. Anderson, Fairmont Mfg. Co., Fairmont, W. Va.
E. P. Arthur, Morgantown.
G. R. Bancroft, Head of Department of Physiological Chemistry at W. V. U.
W. D. Barrington, Consolidated Coal Co., Fairmont.
John Beck, Graduate Student and Assistant in the Agricultural College at W. V. U.
G. A. Bergy, Professor of Pharmacy at W. V. U.
C. F. Brown, Chemistry Major at W. V. U.
E. F. Chase, Science Teacher, Broadus College, Philippi, W. Va.
F. E. Clark, Head of Chemistry Department at W. V. U.
A. R. Collett, Assistant Professor of Chemistry at W. V. U.
G. L. Craig, Chemist, Fairmont, W. Va.
W. F. Dalzell, Fostoria Glass Co., Moundsville, W. Va.
E. C. H. Davies, Associate Professor of Physical Chemistry at W. V. U.
Lily Bell Sefton Deatricks, Associate Professor of Chemistry at W. V. U.
P. J. Donham, Chemist, Domestic Coke Co., Fairmont, W. Va.
R. B. Dustman, Head of Agricultural Chemistry Department at W. V. U.
D. L. Farnsworth, Science Teacher, Barrackville, W. Va.
C. E. Garland, Assistant Professor of Organic Chemistry at W. V. U.
J. A. Gibson, Jr., Instructor of Chemistry at W. V. U.
A. B. Gould, Science Teacher, Salem, W. Va.
Gordon Graham, Broadus College, Philippi, W. Va.
J. P. Graham, Graduate Student of Chemistry at W. V. U.
L. P. Hansen, Assistant Chemist, Experiment Station.
Darrell Hill, Graduate Student and Assistant in Chemistry at W. V. U.
W. W. Hodge, Head of Department of Chemical Engineering at W. V. U.
C. A. Jacobson, Professor of Chemistry at W. V. U.
B. B. Kaplan, Chemist West Virginia Geological Survey, Morgantown, W. Va.
C. L. Lazell, Assistant Professor of Chemistry at W. V. U.
S. Morris, Professor of Chemistry at W. V. U.
H. A. H. Pray, Instructor of Chemistry at W. V. U.
E. W. Riblett, Graduate Student and Assistant in Chemistry at W. V. U.
H. F. Rogers, Professor of Chemistry, Fairmont State Normal College.
L. C. Shriver, Experiment Station, Morgantown.
H. J. Sigwart, Paper Chemist at Richwood, W. Va.
Steele, W. D., Morgantown, W. Va.
Kenneth Taylor, Graduate Student and Assistant in Chemistry at W. V. U.
R. W. VanKirk, Graduate Student and Assistant in Chemistry at W. V. U.
G. H. Way, Chemist, Wheeling Steel Corporation, Wheeling, W. Va.
Ira S. Young, Student at W. V. U.

DETERMINATION OF THE FINENESS OF MARL AND
GROUND LIMESTONE*E. P. DEATRICK AND CLARENCE DORMAN¹

Liming the soil is a very old operation. The first of the liming materials to be used was naturally the soft form of calcium carbonate, the chalks and marls. As the practice of liming spread to sections far removed from the natural beds of these soft limes, the custom of crushing or burning limestone developed. With the use of crushed limestone there arose the question of the relative effectiveness of different sizes of the crushed product. Crushed limestone is easily sieved through various screens. Numerous tests have therefore been run in the field to determine the effectiveness of the material passing through these screens. It is commonly accepted that crop yields from such tests indicate that crushed limestone passing through a screen having 60 meshes to the inch is about 75 per cent as effective as that passing through a 100 mesh screen.

Department of Agriculture laboratories, charged with making analyses of lime materials so as to check up on the guarantees of the companies selling lime, generally determine the calcium and magnesium carbonate content and the fineness. Portions of the marl or the crushed limestones are thoroughly dried and sifted through a battery of screens of 20-40-60-80, and 100 mesh and the results are reported in percentage of material passing through or held on the screens.

The accuracy of the dry screening test for the determination of the fineness of marl has been questioned by some control chemists as well as by some marl producers. The dry screening test as generally run is inaccurate. Accurate results cannot be obtained, for a large portion of the largest pieces

¹Associate Professor and Graduate Student in Agronomy (Soils).

*Approved for publication as paper No. 47 by the Dean and Director, West Virginia Agricultural Experiment Station. Received for publication, 1928.

of marl are not solid. They are balls or granules of finer particles which to a great extent have been formed during the commercial drying process. Recognizing this, the details of the method of screening seems to vary in different laboratories. In one laboratory the marl is gently rubbed through the screens with a rubber pestle. In another the marl is constantly agitated with a spoon handle or similar instrument, but no attempt is made to "force the particles through the mesh or break them down in any way." That there is a disagreement in the results of repeated determinations of the dry screening test is shown by the following data.

PERCENTAGE OF MATERIAL PASSING THROUGH A 100 MESH
SCREEN (DRY METHOD)

Marl	1st trial	2nd trial	3rd trial
"Lime marl"	45	58	64
"Alba marl"	23	21	28

These figures were obtained by merely shaking the screen until apparently very little material came through. It is really difficult to determine when further shaking is not effective. It has therefore seemed that a better method could be devised. The fact that marl so closely resembles soil suggests the application of at least part of the method used in the determination of fineness of soil. In this method the granules or floccules are broken up by shaking in water to which a deflocculating chemical is added. Consequently, the marls on hand were first deflocculated. This was accomplished by stirring 10 grams of dried marl in 500 cc of water, to which 5 cc of N/10 KOH solution was added, for 15 minutes in a motor drink mixer as modified by Bouyoucos.¹ The deflocculated material was immediately poured onto a 100 mesh screen. In this work, one of the determination of a principle, the material passing through the screen was discarded. The screen with the material held thereon was dried and weighed. The difference between this weight and that of the empty screen was

¹Bouyoucos, G. J. Directions for determining the colloidal material of soils by the hydrometer method. *Science* 1927, Vol. LXVI, No. 1696, pp. 16-17.

subtracted from 10 and multiplied by 10 to secure the percentage of material passing through the screen. Inasmuch as the smallest 100 mesh screen available in this laboratory was five inches in diameter, it was impossible to make weighings on an analytical balance. Therefore, all data here given are based on weighings accurate only to one-tenth of a gram. The data given below, however, clearly show that not only can better checks be obtained but that the error in the dry screening method is considerable. In the case of the "Alba marl" not more than about one-fourth of the 100 mesh material was determined as of that fineness, by screening dry.

PERCENTAGE OF MATERIAL PASSING THOUGH A 100 MESH
SCREEN (WET METHOD)

Marl	1st trial	2nd trial	3rd trial
"Lime marl"	94	93	93
"Alba marl"	89	90	92

It is recommended, therefore, that a battery of screens of small diameter be secured so that weighings can be made with an analytical balance. Small aluminum or brass screens can be secured on special order from several of the scientific apparatus companies. If the weight of each screen be determined, the deflocculated marl should be poured on to the 20 mesh screen at the top of the "nest." The water carrying the finest material through the bottom 100 mesh screen should be caught in a beaker, and evaporated. The battery of screens with the marl caught thereon, can be dried, shaken to insure more accurate separation (the additional portion passing the 100 mesh screen being added to the beaker), and all separates finally weighed. Thus a complete check on the accuracy of the individual determinations may be obtained.

One would logically reason that the 100 mesh material in ground limestone could be somewhat more accurately separated from the coarse material by screening a suspension. The difference in the results obtained by using the two methods is shown here as being significant. The magnitude of the

difference in the case of limestone, as expected, is however not as great as in the case of marl.

PERCENTAGE OF "STANDARD LIMESTONE" PASSING A 100
MESH SCREEN

Trial	Dry method	Wet method
1	58	67
2	59	68
3	59	67

CONCLUSION

It is clearly seen that it is impossible to accurately separate the fine from the coarse material by dry screening and that the error is greater in the case of marl than in the case of ground limestone. It is recommended in screening limestone and marl that the samples be deflocculated and that the material be screened while the finer portion is in suspension.

TASTES AND ODORS IN WATER SUPPLIES WITH
SPECIAL REFERENCE TO WASTE LIQUORS
FROM BY-PRODUCT COKE PLANTS

W. W. HODGE

Professor of Chemical Engineering

Paper delivered before the West Virginia State Conference of Water Works Superintendents and Filter Plant Operators at Charleston, West Virginia, November 12-13, 1926, and before West Virginia University Scientific Society December 3, 1926.. In press, Proceedings of West Virginia Conference on Water Purification.

To secure an adequate supply of safe, potable water has been one of the primary problems of man since his creation. Historical and archaeological researches* reveal the efforts of the peoples living in ancient times in Egypt, India and Rome to secure and maintain suitable water supplies. As a general rule the engineers of those days went to uncontaminated sources, even though they were many miles distant, to obtain the water for their large cities. Excavated ruins indicate that Anuradhapura, (437 B. C.-750 A. D.) capital of Ceylon, secured its water supply from impounded lakes and reservoirs some fifty miles away and H. Herschel has estimated that the Romans (312 B. C.-226 A. D.) constructed 381 miles of aqueducts to bring in the average of approximately thirty-eight million gallons of water per day required by the "Eternal City." There is also evidence that filtration on a small, usually domestic, scale was used to aid in purifying the water.

In America today some of our large cities have also adopted the plan of going to sources of pure water even though at considerable distances from the place of utilization. New York City, Seattle, Portland, Ore., San Francisco and Los Angeles are some of the cities which secure their supplies of water from distant sources. However, the majority of our American cities secure their water from nearby sources and depend on modern methods of sedimentation, flocculation,

*Numbers in superior figures refer to the references in the bibliography at the end of the paper.

filtration, and sterilization controlled by physical, chemical and bacteriological tests to produce a satisfactory effluent. With the rapid development of our industrial civilization and little control of the disposal of community and industrial wastes the making of a good potable water from the badly contaminated nearby sources is an ever pressing problem to many of our water works men.

We do not have time in this paper to discuss the many methods and improvements in sedimentation and filtration processes that have developed during the past half century. We will have to limit ourselves to a resume of some of the investigations which have been carried out to determine the cause of certain bad tastes and odors occurring in water supplies and the best methods to remedy the troubles.

In an article by N. J. Howard² of the Toronto Water Works, he gives several classes of materials causing bad tastes or odors in water. These are as follows:

1. Excessive algae growth in the water.
2. Formation of compounds following treatment of the water with chlorine.
3. Presence of an excess of iron compounds in the water.
4. Calcium sulfate in the presence of certain kinds of organic matter.
5. Presence of certain dissolved gases in the water.
6. Various industrial wastes emptied into the streams.
7. Chloramines present in the water.

(1) Cases of disagreeable tastes and odors occasioned by the secretions or by the decomposition of micro-organisms are world wide. The number of algae and other micro-organisms causing trouble is large and fairly well known. However, the description of the tastes and odors varies greatly with the

individual describing it. For instance in January, 1922, when two of New York City's water reservoirs (the Kensico and the Ashokan) were contaminated with *Synura* the following tastes were complained of by different citizens;³ like the faint sweet taste of green grass; that of muskmellon, of cucumber, fish like, a cod liver oil taste, a bitter taste like strychnine, like herring, similar to water mellon rind; and odors like a green grocers establishment, an unadulterated aquarium and a Chinese fishing village. Tests have shown that there was present only 1 part of the unpleasant tasting oil in 200,000,000 parts of the water. In 1904 and 1905 Brooklyn, N. Y., water supply was affected by *synura*. New York City previously had troubles from the diatoms, *asterionella* and *tabellaria* which impart geranium like tastes to the water. *Crenothrix* which thrives in iron pipes containing water causes bad tastes and also hinders the flow of the water. Some two years ago the Fairmont, W. Va., Water Station reported filtration troubles caused by an over abundance of cyclops. Some micro-organisms causing tastes and odors in water supplies are given in the following tables:

ODORS IN WATER SUPPLIES⁴

(From Whipple; Microscopy of Drinking Water)

GROUP	ORGANISM	NATURAL ODOR
Aromatic Odor	Diatomaceae	
	<i>Asterionella</i>	Aromatic—geranium—fishy
	<i>Cyclotella</i>	Faintly aromatic
	<i>Diatoma</i>	Faintly aromatic
	<i>Meridion</i>	Aromatic
	<i>Tabellaria</i>	Aromatic
	Protozoa	
	<i>Cryptomonas</i>	Candied Violets
	<i>Mallomonas</i>	Aromatic—violets—fishy
Grassy Odor	Cyanophyceae	
	<i>Anabaena</i>	Grassy and moldy—green-corn—nasturtiums, etc.
	<i>Rivularia</i>	Grassy and moldy

GROUP	ORGANISM	NATURAL ODOR
Fishy Odor	Clathrocystis	Sweet, grassy
	Coelosphaerium	Sweet, grassy
	Aphanizomenon	Grassy
	Chlorophyceae	
	Volvox	Fishy
	Eudorina	Faintly fishy
	Pandorina	Faintly fishy
	Dictyosphaerium	Faintly fishy
	Protozoa	
	Uroglena	Fishy and oily
	Synura	Ripe cucumbers-bitter and spicy taste
	Dinobryon	Fishy, like rockweed
	Bursaria	Irish moss-salt marsh-fishy
	Peridinium	Fishy, like clam-shells
	Glenodinium	Fishy

(2) Formation of compounds following the sterilization with chlorine. Some of these compounds have much more pronounced tastes than either of the original substances. Chlorination of the water appears to enhance the taste imparted to water by certain micro-organisms as well as that given by some kinds of industrial wastes. For instance the taste given to water by synura is usually not noticed until the organisms are more abundant than 60 per cubic centimeter, but Dr. Hall, Chief of the Bacteriological Department of the New York City Water Board suggests³ that chlorination makes the taste perceptible when smaller numbers of the organisms are present. Dr. E. F. Kohman, Director of the Research Laboratory of the National Canners Association, has published an article⁵ dealing with chlorine phenol tastes, as they have affected certain food canning industries. In his paper he gives the results of tastes produced by phenol, meta and para chlorophenol and trichlorophenol. These compounds could be tasted in dilutions of 1 part per million (p.p.m.) but not when diluted to 1 to 10,000,000 parts water. Ortho-chlorophenol imparted taste to the water in dilutions of 1 part in 10,000,-

000, but not in 50,000,000 parts water. 1-2-4 dichlorophenol gave tastes at 1 part in 50 million, but not in 1 part to 100 million parts of water. Phenol when diluted in 1 part in 750 million parts of water and then chlorinated gave a much more pronounced taste than any of the other combinations tested at the dilutions given.* The taste was also distinctly different from that of any of the other products. To produce this maximum taste the phenol must be in high dilution. Phenol (carbolic acid) in concentrations greater than 1 part in 50,000,000 is phenolic in taste like the chlorophenols given above, and with high dilution there must also be the proper concentration of chlorine. A little excess chlorine completely destroys the taste. Kohman concludes that "phenol and chlorine under these conditions react differently than they have heretofore been known to react. It would seem that either one of the phenols other than 1-2-4 dichlorophenol is formed, or there results an entirely new product. This compound has also a very penetrating odor. In approaching the water works plant on certain days the odor was pronounced at 20 to 30 feet from the door. To the new comer the odor was evident in the canning factory using the chlorinated water on account of the steam exhaust boxes although the people working in the factory were unaware of the odor." This emphasizes the necessity for food manufacturers to guard against the use of water which is chlorinated after the water has been contaminated with certain types of organisms or of industrial wastes. Since the phenols occur in coal tar wastes they are referred to again under Group No. 5.

(3) The presence of considerable amounts of iron compounds has long been known to impart tastes to water. The peculiar taste of some artesian well waters is due to the iron compounds they contain and the same holds true for certain bottled chalybeate mineral waters. Howard² states that the presence of iron in water in excess of 2 p.p.m. gives it an inky taste. Iron in water which also carries sulfid wastes from

*American Gas Association, 1920 Committee Report states that still waste phenol, when diluted with tap water, chlorinated and boiled, could not be tasted if diluted with more than 75 million parts of water to 1 part of phenol.

paper mills, tanneries, or other industries blackens the water and intensifies the disagreeable odors. The micro-organism, crenothrix, is also likely to thrive too abundantly in waters high in iron content, and this organism imparts bad tastes to water. Aeration followed by sedimentation or filtration is a fairly cheap method for removing excessive iron content from water.

(4) Calcium sulfate in waters also containing certain kinds of organic matter is reduced by the organic matter to a calcium sulfid, even at ordinary temperatures. Then if much carbon dioxide is present in the water this carbonic acid reacts on the calcium sulfid producing some hydrogen sulfid in the water thus giving the water a disagreeable taste and odor. Certain other sulfates probably react similarly, but have not been sufficiently studied as yet to make definite statements regarding exact reactions which occur.

(5) Gases such as hydrogen sulfid, ammonia, sulfur dioxide, chlorine when dissolved in water are among those chemicals which either themselves or by reaction with other substances often present in water supplies impart disagreeable tastes or odors. Aeration or special chemical treatments are used to remove gases from the water supplies.

(6) Group six is given as various industrial wastes, and certainly is worded so as to cover a multitude of sins. We will mention merely the more common industrial wastes many of which under favorable conditions impart bad tastes and odors to water supplies.

(a) Mine wastes⁶—the waters from the mines often contain free acid and excessive amounts of iron compounds.

(b) Sewage pollution—rivers are sometimes loaded too heavily for the self-purification action of the stream. This danger should be guarded against in West Virginia where the acid mine waters and other wastes from industries often hinder the natural work of the micro-organisms and oxygen

toward purifying sewage. We should look forward to having more sewage disposal plants in our cities.

(c) Tannery wastes—a black greenish slime, scraps of skins, hair, decaying bits of other animal tissues, and a sulfid waste liquor all combine to give bad tastes and odors to the streams into which such wastes are emptied. These tannery wastes should be treated properly before being dumped into rivers from which cities further down stream secure their potable water supplies. The use of Traver's process marl filters* has proved of value in purifying waste liquors from some tanneries. Others have found that by piping the acidic waste liquors into tanks with the basic liquors from the liming pits the objectionable materials in both types of waste liquors are precipitated. These solids are collected in settling basins and a clear practically neutral waste liquor is drawn off and discharged into the sewers or streams. An English system of using sand, gravel and straw in the filter bed through which the tannery waste liquors are passed has helped the removal of objectionable materials at some plants; as have other types of filters including simple marl treatments. However, there is still much to be done before we have satisfactory methods by which all types of tannery wastes can be profitably treated before discharging them into streams.

(d) Oil wells and oil refineries—When oil wells are first drilled the salt waters and first oil flowing is often run into our streams. At the refineries the sodium hydroxide and plumbite wash waters and the sludge from the sulfuric acid wash are frequently dumped into the rivers. The oil films formed often cause filter bed troubles at water stations, give an oily taste to the water; kill the fish and other forms of aquatic life, and increase fire risks. The new pipe line bringing the water from Tibbs Run reservoir to Morgantown, W. Va., was constructed from pipe previously used for a short time in an oil pipe line. Each length of pipe and the fittings were burned out before connecting them into the new water line.

*Private communication from Mr. A. B. Brooks, formerly Chief of West Virginia Fish and Game Commission.

but in spite of this precaution the water from this source had a rather unpleasant oily taste for weeks following the opening of the new line.

(e) Wood distillation plants often run some wastes containing creosote oils into the rivers. These creosote oils contain phenolic compounds which are toxic to fish and if very concentrated will kill all plant and animal organisms; also they act much like the phenols from coal tar (j) causing bad tastes in water supplies.

(f) Pulp and paper mills run enormous amounts of waste waters into our rivers up to as high as 6000 times the weight of pulp produced. The nature of these waste waters varies widely depending on whether the mills are making ground wood pulp, sulfite, soda or sulfid pulp. The waste waters may carry excessive quantities of saw dust, small chips and bark, lignin, lime, sulfites, sulfates and sulfids, all substances deleterious to water supplies and most of them imparting disagreeable odors and tastes to the water.*†

(g) Creamery wastes do not occur to any great extent in West Virginia. Putrification of creamery wastes cause bad tastes and odors in water supplies. Since methods are available for conserving and profitably utilizing every constituent of milk except the water in it there is no excuse for discharging anything but water and washings from creameries and cheese factories.

(i) Glass factory waste liquors seldom impart bad tastes or odors to water supplies. We have tested several samples and none of them imparted perceptible tastes in dilutions of 100 parts of water to 1 part of the glass factory waste liquor.

(j) By-product coke oven plants and gas works wastes have in recent years caused much trouble to water works companies because of the bad tastes and odors which such wastes

*For the results of recent cooperative studies on methods of treatment and disposal of wastes from:—sulfite pulp mills; pea canneries and knitting mills the reader is referred to the bulletin "Stream Pollution in Wisconsin," Bur. of Sanitary Eng'g., Wisconsin State Board of Health, Jan. 1927.

impart to the water. The waste liquors from by-product coke plants and gas works contain phenolic and amino bodies which produce tastes and odors in water and these tastes and odors are often intensified when the water is treated with chlorine. The chlorine appears to combine with the phenols giving disagreeable tasting chlorophenols (Group 2) and also combines with some amino compounds producing equally offensive chloramines (Group 7). Many cities have in the past ten years had bad tasting water due to the content of by-product oven and gas works wastes. Among such cities are Milwaukee, Wisconsin⁸ in 1918-19, South Chicago⁵ in 1920-21, Toronto, Canada² in 1920-22, South Pittsburgh in 1921-22, Cleveland, Ohio⁹ in 1923-24, Wheeling, West Virginia in 1920-25, and other Ohio valley cities. In Morgantown our investigations indicated the occurrence of bad tastes in our city water supply were largely due to waste liquors from the by-product coke plant at Fairmont. These waste liquors were emptied into the Monongahela River some twenty miles from Morgantown, but persist in the river at our water station intake and were even blamed by the South Pittsburgh Water Company for some of the disagreeable tastes in their water supply. The results of some of the experiments we carried out in the Department of Chemical Engineering at West Virginia University on this by-product waste liquor are given in the following tables:

Table 1

TASTE TESTS ON BY-PRODUCT WASTE LIQUORS—NO. 2

Tests made October 25, 1923. There was no bad taste in the city water on this day so it was used and small portions of the by-product waste liquor (collected October 16, 1923) were added, dilutions made as shown in the table. The beakers were numbered as indicated. The students in the squad (mostly seniors in the Chemical Engineering course at West Virginia University, did not know which of the beakers were plain water and which contained by-product waste liquor. Each man in the squad did his tasteing independently, not knowing the results of any other man's tests. The water was collected at noon on October 24, 1923, from the clear well or cistern at the Water Works Station, just after the chlorine was administered. The dilutions were made at about 8 p. m. Plus (+) indicates disagreeable taste noticeable; minus (—) no disagreeable taste observed. Results were as follows:

Number of Beaker									
Student	1	2	3	4	5	6	7	8	9
J. B.	—	+	+	—	+	+	+	++	+++
F. B.	trace	+	+	+	+	+	++	++	+++
W. Z. F.	—	++	+	—	+	++	++	+++	++
J. P. J.	—	+	+	—	++	++	+	++	+++
L. H. K.	—	—	+	—	—	+	++	+	+
W. T. K.	—	+	+	—	+	++	++	+++	++
P. B. S.	—	+	—	—	—	—	++	++	++
R. C. S.	—	+	+	—	++	+	++	++	++
G. S.	—	+	+	—	+	++	++	++	++
Key to dilutions in beakers	H ₂ O only	1: 5,000	1: 3,000	H ₂ O only	1: 2,000	1: 1,000	1: 500	1: 200	1: 100

Remarks: From these results it is evident that all but one of the tasters detected the presence of the by-product waste liquor at a dilution of 1 part of the waste to 5000 parts water.

This table was incorporated in my report to the West Virginia Utilities Co. It was published in the Morgantown New Dominion, Nov. 14, 1923.

Table 2

TASTE TESTS ON BY-PRODUCT WASTE LIQUORS—NO. 5

Tests made, November 10, 1923 and compared with taste of the city water as obtained from the faucet on November 8th when the city water had a very unpleasant taste. Water used was obtained from the clear well at the water station on November 10, 1923, before any bad taste was present in the water. Small quantities of the by-product oven waste liquors were added to the water in the numbered beakers and tests made independently by each student on our so-called "Poison Squad" as described in previous experiments.

Number of Beaker												How like the faucet water of 11-8-23
Student	1	2	3	4	5	6	7	8	9	10	11	
J. B.	—	+	+	+	trace	—	—	++	—	++	++	No. 8
F. B.	oily	+	+	+	+	— ? +	++	+++	++	++	++	No. 11
W. Z. F.	—	+	+	++	—	++	++ +	++	—	++ +	++	No. 10
J. P. J.	—	++	+	++ +	—	++ +	++ +	+++ ++	—	+++ ++	+++ ++	No. 6
W. T. K.	—	+	+	+	—	+	++	++ +	—	++ ++	++ +	No. 8
C. R. M.	—	—	—	—	—	+	+	++	— ?	++ +	++ ++	No. 7
P. B. S.	—	++	—	—	—	++	—	+	—	—	+++	No. 6
R. C. S.	—	+	+	—	—	+	—	++	++	++ ++	+++ ++	No. 9
Key to dilutions in beakers	H ₂ O alone	1: 10,000	1: 5,000	1: 4,000	H ₂ O alone	1: 2,000	1: 1,000	1: 500	H ₂ O alone	1: 200	1: 100	

Remarks: In this set of tests all but one of the eight tasters detected the by-product waste in the 1:10,000 dilution. Also, while the individuals differ as to the beaker whose contents taste most like the city water on November 9, 1923, yet it is noticeable that no one places the taste of the city water as being better than No. 6 in the table.

In addition to the experiments made on the by-product oven waste liquors we carried out taste and odor tests on some 17 other samples collected from streams of industrial wastes or "runs" emptying into the Monongahela River between Morgantown and Fairmont. These samples included waste liquors from glass factories, coal mines, a large power plant, and numerous other types of discharges. None of these other samples imparted any bad taste to the water at dilutions greater than 1 to 50 parts of water and the tastes then given were not like the one characteristic of Morgantown's city water on certain days.

From our tests the by-product waste appeared to be the material chiefly, but probably not wholly, to blame for the disagreeable taste in the Morgantown city water. We, therefore, in cooperation with the State Health Department took up with the Domestic Coke Corporation of Fairmont the matter of trying to dispose of the waste liquors from their plant in some manner other than by running them into the Monongahela River. A conference was held in Fairmont at which there were present representatives of the Domestic Coke Corporation, West Virginia Utilities Company (which supplied Morgantown with water), the South Pittsburgh Water Company, the Engineering Division of our State Health Department, the City of Morgantown, and a representative of the American Water Works Association from New York City. As a result of this meeting the By-products company officials assured us they would gladly cooperate in any reasonable way to stop running the by-product waste liquors into the Monongahela River.

The corporation has sent its superintendent, Mr. Gericke and other engineers and their chief chemist to many by-product coke oven plants in several different states to study methods of disposing of these phenol bearing waste liquors. At the time this investigation was made there were three general methods of treating the liquors other than emptying them into bodies of water used for city water supplies.

1. Running the liquors into sedimentation or impounding reservoirs large enough so that surface evaporation and seepage would take care of the daily addition to waste liquors. The topography of the lands adjacent to or near the Fairmont plant was not suitable for the application of this method.

2. Recirculating methods—collecting the waste liquors from the lime towers and tar machines and the water left from quenching coke into large concrete basins or sumps and pumping this up again and using it in quenching the coke. This was tried on a small scale at the Fairmont plant but the residual liquors left a bad odor and lumps of brownish material on the coke. These odors and spots would not hurt the coke for blast furnace use but they spoiled it for sale in the domestic coke trade which made up quite a portion of the Fairmont plant's business. So this method of utilizing the waste liquors had to be abandoned. The Company did, however, construct two large concrete sumps at the quenching tower and recirculated the quenching water and this materially reduced the quantity of waste liquor run into the river.

3. The third method was that of emptying the by-product plant waste liquors into the city sewers and depending upon the action of the sewage bacteria to attack and destroy the phenols. The location of the by-product plant in relation to the layout of the Fairmont sewage system was not favorable to the use of this method of disposal. Furthermore if the phenols become sufficiently concentrated in the waste liquors their antiseptic action would retard the action of the bacteria of the sewage and hinder the self purification of the water in the Monongahela River, since the Fairmont sewers empty into this same river as do the by-product plant wastes.

Apparently there would be in Morgantown no immediate relief from the bad tastes caused by the presence of the by-product plant waste liquors (wier readings showed these amounted to about 1,500,000 gallons per day) in the Monongahela River. Consequently the West Virginia Utilities Com-

pany, after a careful study of the run off and quality of water obtainable from the Tibbs Run water shed laid a larger pipe line to their reservoir located on this stream, some seven miles from Morgantown. This gives the city a supply of uncontaminated mountain water for about nine months of the year. It is a much finer quality of water than can ever be obtained from an industrial wastes river like the Monongahela even if the by-product plant wastes were entirely eliminated. However, the quantity available is not sufficient during the summer months and the larger percentage of the city's supply during this season has still to be pumped from the Monongahela River.

During the years that the Utilities Company was developing the Tibbs Run Water supply the Domestic Coke Corporation continued its efforts to find a satisfactory method for disposing of their phenolic waste liquors. Several new processes were proposed for the recovery of the phenols from the coal tar and the still waste liquors. Two of the most promising were: R. M. Crawford's¹⁰ method, scrubbing the tar distillates with sodium sulfide which formed sodium phenates with the phenols (and cresols) present. The phenates are then treated with H_2S which reacts to free the phenols and reforms the sodium sulfide. Another method uses benzol applied in counter current scrubbing towers to remove the phenols from the still waste liquors. To the benzol solution of phenols sodium hydroxide is added and it reacts on the phenols and cresols to form sodium phenates and cresates which are insoluble in the benzol and are separated from it. The recovered benzol goes back to the scrubbing towers. The phenates are treated with sulfuric acid which reacts to form sodium sulfate and free the phenols, which are then drawn off from above the sodium sulfate solution. The recovered phenols can be sold in the crude state or can be refined by steam and fractional distillation.

Experiments carried out by the By-product Corporation's chemists and engineers led to the selection of the benzol

method for recovering the phenols. A large new unit is now (November 12, 1926)* under construction at their plant and when it is completed the waste liquors which the by-product company empties into the Monongahela River will contain only a small percentage of the bad taste generating phenols which they have heretofore contributed to the water supplies of Morgantown and other cities farther down stream.

In this paper we have contrasted the custom of ancient peoples of securing their city water supplies from pure sources, even though far distant, with the modern plan of applying chemicals and filtration to purifying polluted water obtained from nearby sources. We have briefly discussed a number of the commonest forms of pollutions which often cause bad tastes and odors in water supplies. We have given the results of our investigation by which we found the main cause of the disagreeable tastes in Morgantown's City Water could be traced to the by-product coke oven wastes emptied into the Monongahela River some twenty miles upstream. And, finally we have shown how by scientific research and cheerful cooperation between the Department of Chemical Engineering of West Virginia University, the State Health Department and the Domestic Coke Corporation a bad case of stream pollution has been stopped, and how the obnoxious substances in the waste liquors is being recovered in a form which has proven to be another valuable by-product.

BIBLIOGRAPHY

1. General references: Water Supply, Wm. P. Mason; Public Water Supplies, Turneure and Russell. Frontinus and the Water Supply of the City of Rome translated by Clemens Herschel. Fresh Water Biology, Ward and Whipple.
2. Modern Practice in the Removal of Taste and Odor from Water. Norman J. Howard. J. Amer. Water Works Assoc, 9, 766-82 (1922). Eng. and Contracting (Waterworks), 58, 43-49 (1922).

*Mr. H. E. Jones, Plant Engineer for the Domestic Coke Corporation has since informed the writer that their phenol recovery unit started operation about the middle of January, 1927, and is maintaining an extraction efficiency of 96% on the phenolic wastes. One thing is sure, here in Morgantown, we now very seldom have any of that formerly very bad medicinal taste in our city water.

3. New York Times. Issues of January 6 to 31, 1922.
4. Microscopy of Drinking Water. G. C. Whipple.
5. Phenol—Chlorine Water Pollution. E. F. Kohman. J. Ind. Eng. Chem. 15, 518 (1923).
6. Stream Pollution by Acid Water from Coal Mines. R. D. Leitch. Bureau Mines; Chemical Division. Report No. 290-H; 121 (1926).
7. Stream Pollution in Wisconsin. Special Report of Bureau of Sanitary Engineering, Wisconsin State Board of Health, Jan. 1927.
8. Seventh Annual Report of Milwaukee Sewage Commission—Hatton and Copeland. Also Engineering News-Record 82, 181—(1919). Interference with Water Filtration Plant Operation by Wastes from By-Product Coke Ovens and Gas Works. C. A. Emerson. Trans. Amer. Soc. Civil Engs., 85, 484-5 and C. B. Baker, 506-8 (1922). Same in Eng. and Contracting, 58, 132-33 (Feb. 1922). Trans. Amer. Soc. Civil Engineers (Dec. 1921 and Jan. 1922) Eng. and Contracting 57, 132-3 (1922) Detected phenol in dilutions of 1:500,000,000. Closing Gas Works Plant discharging phenol wastes gave relief.
9. Foul Tastes in Cleveland Water Again Caused by Phenol. J. W. Ellms. Eng. News-Record 92, 453 (1924) also Ellms & Lawrence, J. Amer. W. W. Assoc. 9, 463 (1922).
10. Recovery of Phenols from Steel Plant Fuel Tars. R. M. Crawford. International Conference on Bituminous Coal. Carnegie Institute of Technology, Pittsburgh, Pa. (Oct. 1926).

FACTORS AFFECTING FRUIT SETTING IN THE APPLE

H. E. KNOWLTON

Associate Professor of Horticulture

Approved as scientific paper No. 58, by N. J. Giddings, Acting Dean and Director, West Virginia Agricultural Experiment Station.

There are many factors affecting fruit set in the apple. Some may have their influence on the initiation and subsequent development of the fruit bud while others affect actual setting of the fruit by their influence on pollination and fertilization of the flower and on the maturation of the fruit. Only a few of the more important factors will be discussed here.

FRUIT BUD INITIATION

Fruit bud initiation starts the season previous to their full development. With the apple the first evidence of this is late in June when a few buds will show the characteristic flattened crown from which shortly flower primordia will arise. Later others start and the process of initiating may continue throughout the summer or until cold weather stops it.

Fruit buds of the apple are, for the most part, produced terminally either on spurs or on longer growths. It is evident, therefore, that growth in length must cease, except possibly that due to cell enlargement, before fruit bud initiation can take place. Evidence is seen for this in the time of development of flower primordia on the different length growths. The very short spurs cease growth earliest and are the first to initiate fruit buds while the long terminals are the last to cease elongating and the latest to initiate fruit buds. It is evident from this that if a shoot continues growing indefinitely no fruit bud will form.

NUTRITIONAL CONDITIONS ASSOCIATED WITH FRUIT BUD INITIATION

Many studies have been made dealing with the nutritional conditions associated with fruit bud development. The results of such investigations have shown that there is a basis for the formation of a nutrition theory of fruit bud formation though

the details of the specific nutritional effects still need to be worked out.

Most of the recent work along these lines has been colored by the chemical studies of Kraus and Kraybill (1918). Vegetative growth and fruitfulness have generally been thought of as being opposed to each other, but these workers have, on the contrary, clearly established their interrelation. They postulate certain conditions regarding growth and fruitfulness based on the relative proportions of carbohydrates and nitrogen available to the plant. They recognize the following four classes into which a plant might fall as regards these proportions.

I. Carbohydrates deficient and limiting, moisture, nitrogen and other mineral nutrients plentiful: Vegetation will be weakened and fruitfulness restricted.

II. Carbohydrates increased above the limiting value, with moisture, nitrogen and other mineral nutrients as in I. The plant will be very vegetative but unfruitful.

III. Carbohydrates very abundant, nitrogen inadequate or limiting growth: Vegetative growth will be less than in II, but conditions will be favorable for initiation of flower buds due to accumulated carbohydrates.

IV. Carbohydrates very abundant, nitrogen still further reduced and now limiting: Vegetative growth and sexual reproduction both at a minimum.

Kraus and Kraybill worked with a tomato, a plant peculiarly fitted for this type of study. With a perennial woody plant like the apple the relationships mentioned above seem more obscure. Harvey (1921) has attempted to determine this, however. The purpose of his study was to find out the relation between the leaves of the individual apple spur and its metabolism as indicated in the carbohydrate-nitrogen relations and fruit bud formation. Chemical analysis at three periods during the summer were made of many blossoming and non-blossoming spurs. Defoliation was practiced to modify

carbohydrate content. He found that defoliation markedly reduced the percentage of spurs developing fruit buds and lowered the value of the carbohydrate-nitrogen ratio. However, the writer believes that "no rigid interpretation of a carbohydrate-nitrogen ratio is justifiable at the present time," although he believes that it will apply to perennial as well as to herbaceous plants.

A brief review will be given of some of the more important investigations on this problem. Hooker (1920) followed the seasonal changes in the composition of apple spurs through the usual two year cycle. He found appreciable quantities of starch accumulating only in spurs which were presumably differentiating fruit buds. Starch nitrogen relations characteristic of fruit bud initiation and of leaf bud differentiation were found on the same tree indicating that fruit spurs behave largely as units and that the response is conditioned largely by local carbohydrate-nitrogen relations. Kraybill's (1923) more recent studies with both apple and peach indicate lower soluble nitrogen, insoluble nitrogen and total nitrogen and higher reducing substances, sucrose, starch and acid hydrolyzable polysaccharids with higher percentages of fruit bud formation.

All of these investigators may be criticised on their method of taking spur samples for no attempt was made to select spurs as to age or total growth made. Harley (1925) found a much higher coefficient of variability in the chemical composition of spurs of variable lengths and age than in samples of spurs of the same length and age and a much higher variability in old than in new growths. He felt that when old growths are included in spur samples a variable factor is introduced which may obscure significant differences in the new growth. Harley found non-bearing spurs at time of fruit bud initiation to be relatively high in starch as compared to nitrogen content, while bearing spurs at the same period were relatively low in starch as compared to nitrogen content. Potter and Kraybill (1925) in their New Hampshire experiment

find that the carbohydrate-nitrogen ratio of spurs that Harvey found most fruitful to be almost exactly similar to that of the non-bearing spurs of trees in sod. They believe that the dominance due to the developing fruit which may have an inhibiting effect upon lateral bud development should be considered. It would seem also that the nutritional conditions found in spurs of Kraus and Kraybill's Class 1 and 4 need investigation. Possibly such studies would furnish more information regarding the internal balance of carbohydrates and nitrogen than would studies of biennially bearing spurs and would avoid the "dominance" of the developing fruit.

Fruit bud formation has also been studied in its relation to leaf area and spur growth. Magness (1916) and Roberts (1920) have shown the dependence of fruit-bud formation on the photosynthetic activity of adjacent leaves. Roberts has divided spurs into four classes as far as blossom bud formation is concerned, (1) under-vigorous spurs (short spurs which usually bear terminal leaf buds), (2) vigorous non-fruiting spurs (medium length spurs which generally form blossom buds but seldom fruit), (3) vigorous fruiting spurs (medium length spurs which blossom and usually set fruit), and (4) over-vigorous spurs (long spurs, some or many of which have terminal leaf buds). He explains this classification in terms of the carbohydrate-nitrogen ratio theory showing growth is related to leaf area and thence to carbohydrate accumulation. Dorsey and Knowlton (1925) have also studied this relationship. Their work agrees with that of Roberts in certain respects in that spurs of so-called "spur bearing" varieties fall into these groupings while "terminal bearing" varieties do not, particularly as regards class 4. Working with Rome they found no over-vigorous spurs. Roberts (1926) claims that varieties that bear terminally generally have large terminal leaves.

While the evidence available so far (Kraus and Kraybill, 1918) (Gurjar, 1920) would indicate that with herbace-

ous plants there may be a fairly definite carbohydrate-nitrogen ratio associated with fruit bud initiation this evidence is not so convincing with perennial plants like the apple. It would seem, therefore, that all one is justified in concluding at the present time from the evidence at hand is that fruit bud initiation is associated with carbohydrate accumulation and a cessation of growth. We have no information as to which of these associated phenomena is cause and which is effect.

FRUIT BUD DEVELOPMENT SUBSEQUENT TO BLOSSOMING

After initiation growth of the fruit bud proceeds rather rapidly until late fall when low temperatures retard or almost prevent it. Even during the so-called "rest period" growth continues slowly even though there is no marked increase in size of bud. There is indirect evidence (Knowlton and Dorsey, 1928) that those buds which initiate latest grow at the fastest rate. This tends to bring about a uniform stage of development of all buds by blossoming time.

Little investigational work has been done dealing with the nutritional conditions associated with the growth of the fruit bud during this period. It is believed, however, that favorable weather conditions in late summer and fall have much to do with the development of strong buds.

BLOOMING

The order of blooming on the various length growths is the same as for initiation of the fruit bud, i. e., first on the shortest spurs and last on the longest terminals. The range in time, however, is shorter (perhaps three months for initiation and four to ten days for blooming) indicating different rates of development up to this period.

SELF-STERILITY AND FRUIT SETTING

All varieties of apples on which data are available are self-sterile or partially so. This is evidenced by the fact that all give greater sets of fruit when cross-pollinated. There are variable degrees of incomplete sterility. Delicious on the one

hand is almost completely self-sterile, while York and Ben Davis are self-fertile to a high degree. Other varieties will be somewhere between these two extremes. It should be emphasized that the commercial orchardist is not greatly interested in this partial sterility. The important thing to him is a set large enough to insure a crop of fruit. This may obtain with many of the partially sterile varieties since a 10 to 15 per cent set is generally sufficient.

SELF-STERILITY DUE TO INCOMPATIBILITY

Most apple varieties are self-sterile due to so-called self-incompatibility. Knight (1917) noted that with certain varieties like Rome the pollen tube grew more slowly when selfed than when pollen of another variety was used. East (1918) found similar conditions to exist with Nictiana. Roberts (1926) working with Wealthy apple found that it was not rate of growth that prevented fertilization but actual cessation of growth which prevented the male nuclei from reaching the ovules. Even after many days the pollen tubes in selfed Wealthy flowers did not go more than one-third to one-half the way down the styles. Difference in growth rate between crossed and selfed pollen tubes were evident when they were about one-quarter down the style.

SELF-STERILITY DUE TO POLLEN ABORTION

Many of our varieties of apple are self-sterile because of a lack of functioning pollen. Of the standard varieties that have this defect those of the Winesap group are most important, viz., Winesap, Stayman and Arkansas (Black Twig). Apparently this is because of a genetic rather than a nutritional condition. Shoemaker (1925) suggests that Stayman may be an example of a polyploid form of apple.

INTER-STERILITY AS A CAUSE OF POOR SET

By inter-sterility is meant the condition that exists when certain varieties are unable to cross fertilize each other. This condition is fairly common in the sweet cherry and almond.

Only a few cases, however, have been well established with the apple. Probably the best authenticated case in which incompatibility seems to be the cause is that of Grimes and Black Twig first reported by Auchter and Schrader (1925), and Knowlton (1927) corroborated this. (See Table I.) The failure of Black Twig to fertilize Grimes is undoubtedly due to functionless pollen. The inability of Grimes to fertilize Black Twig is probably due to incompatibility.

TABLE I. SET OF FRUIT ON BLACK TWIG (1927)

Variety cross	Number of Blossoms crossed	Number of blossoms set	Per cent of blossoms set
Black Twig x Delicious	336	116	34.5
Black Twig x Grimes	497	0	0

ENVIRONMENTAL FACTORS AFFECTING FRUIT SETTING

"Weather at the blooming period is one of the most important factors affecting the set of fruit. Winds may seriously delay or entirely prevent cross pollination if bee flight is retarded." (Knowlton and Sevy, 1925). It should be emphasized that apple pollen is heavy and sticky and consequently not wind borne. Insects (chiefly honey bees), therefore, play the sole role in cross pollination. Prolonged rains may delay anther dehiscence as well as prevent bee flight. An unfavorable temperature may, according to Dorsey (1919), influence setting of fruit: (1) its direct effect upon pollen or pistil, (2) its influence upon pollen tube growth, and (3) its interference with bee flight. However, the ultimate result is the same irrespective of what element of the weather is concerned, i. e., fertilization does not take place. Pollination may occur but too late. The pollinizer may produce pollen that grows slowly. Temperature may be low or unusually high resulting in slow pollen tube growth. As a result embryo abortion may occur before the tube reaches the ovules and the flower will fall.

THE SETTING OF FRUIT

Careful examination of a blooming apple tree will show so-called "weak" and "strong" blossoms. The weak blossoms will be found on spurs of very short growth and slender diameter, while the strong blossoms will be borne on spurs of moderate to long growth and thick diameter. Roberts (1926) noted that the weaker blossoms have poorly developed embryo sacs. He also found that it took pollen tubes longer to reach the ovules of weak blossoms than strong blossoms. Auchter's (1921) studies at Maryland show that pollen from vigorous blossoms germinated better than pollen from blossoms of weak spurs. These abnormalities associated with weak spurs would indicate that nutrition is a strong casual factor.

THE DROPPING OF FRUITS

As has been mentioned, from ten to twenty per cent of the bloom on an apple tree sets fruit. Roberts (1926) in an examination of the "drop" fruit of 1922, 1923, and 1924 found the following conditions:

1. The first drop fruits or those which did not develop in size beyond the blossom stage were pollinated but fertilization did not occur because of embryo abortion.
2. Almost all second drop fruits contained small embryos or at least endosperms, indicating that fertilization had occurred.
3. All "June drop" fruits contained seeds having partially developed embryos.
4. The small non-developing ovules of such fruits contained embryos.

That the drop of fertilized fruits is associated with nutritional conditions in the spur cannot be doubted. Weak spurs set a smaller percentage of fruits than vigorous spurs (Heinicke 1917). Spurs with large leaves and spurs having made one centimeter or more growth the previous season set higher per-

centages of fruit. A large percentage of strong spurs set two fruits to the spur than do weak spurs. Detjen (1926) believes lack of pollination and fertilization, supposed to be the chief causes of young fruits shedding, are of little importance. Their importance would undoubtedly vary with the variety and with seasonal conditions.

The internal condition at fruit setting as regards nutrition have also been studied by means of chemical analyses. Contrary to the conditions of a high carbohydrate-nitrogen balance that occur at fruit bud initiation, fruit setting is correlated with low values of this balance. The data of Kraus and Kraybill (1918) show that the parts of the tomato plant closest to the setting fruit were high in nitrogen. Hooker (1920) has also shown a nitrogen maximum in fruit spurs at time fruit is setting. Howlett (1923) found that young apples that were to remain on the tree contained three times as much nitrogen as those destined to drop. It seems fairly conclusive, therefore, that the two important and critical periods in the growing of an apple crop, fruit bud initiation and fruit setting, the carbohydrate-nitrogen relations are directly contrary to each other. This undoubtedly explains why early applications of quickly available nitrogenous fertilizers have such a pronounced effect on set. In the West Virginia fertilizer experiments at St. Marys the following results were gotten (Dorsey and Knowlton, 1926).

	1923	1924
Average Set Nitrogen Plots	26.3	19.8
Average Set Minus Nitrogen Plots	15.4	11.2

In summation one can say that a variety of apple is "born" with a certain hereditary or genetic complex. Upon this complex the various environmental factors play. By studying both the internal condition and external response that various environmental factors affect, more knowledge about the plant's activities is acquired. Having this knowledge the experimenter is in a better position to condition its responses in the line of fruit production.

LITERATURE CITATION

AUCHTER, E. C.

Apple pollen and pollination studies in Maryland. Proc. Am. Soc. Hort. Sci. 1921:51-80.

————— and A. L. SCHRADER

Cross fertilization of the Arkansas (Mammoth Black Twig). Proc. Am. Soc. Hort. Sci. 1925:96-105.

DETJEN, L. R.

Physiological dropping of fruits. Delaware Agr. Expt. Sta. Tech. Bul. 6. 1926.

DORSEY, M. J.

The relation of weather to fruitfulness in the plum. Jour. Agr. Res. 17:103-126. 1919.

————— and H. E. KNOWLTON

The relation of growth to fruitfulness in some varieties of apples. Proc. Am. Soc. Hort. Sci. 1925:161-172.

—————
Fertilization of apple orchards II. W. Va. Agr. Expt. Sta. Bul. 203. 1926.

EAST, E. M.

Studies on self-sterility. II Pollen tube-growth. Genetics 3: 353-366. 1918.

GURJAR, A. M.

Carbon-nitrogen ratio in relation to plant metabolism. Abs. Science N. ser. 51:351-352. 1920.

HARLEY, C. P.

Normal variation in the chemical composition of fruit spurs and the relation of composition to fruit bud formation. Proc. Am. Soc. Hort. Sci. 1925:134-146.

HARVEY, E. M. and A. E. Murneek

The relation of carbohydrates and nitrogen to the behavior of apple spurs. Ore. Agr. Expt. Sta. Bul 176. 1921.

HEINICKE, A. J.

Factors influencing the abscission of flowers and partially developed fruits of the apple (*Pyrus malus* L). Cornell Agr. Expt. Sta. Bull. 393. 1917.

HOOKER, H. D., JR.

Seasonal changes in the composition of apple spurs. Mo. Agr. Expt. Sta. Res. Bul. 40. 1920.

HOWLETT, F. S.

Nitrogen and carbohydrate composition of developing flowers and young fruits of the apple. Proc. Am. Soc. Hort. Sci. 1923:31-37.

KNIGHT, L. I.

Physiological aspects of self-sterility in the apple. Proc. Am. Soc. Hort. Sci. 1917:101-105.

KNOWLTON, H. E., and H. P. SEVY

The relation of temperature to pollen tube growth in vitro. Proc. Am. Soc. Hort. Sci. 1925:110-115.

——— and M. J. DORSEY

A study of the hardiness of the fruit buds of the peach. W. Va. Agr. Expt. Sta. Bul. 211. 1928.

KNOWLTON, H. E.

Studies in apple sterility. Proc. Am. Soc. Hort. Sci. 1927: 111-114.

KRAUS, E. J., and H. R. KRAYBILL

Vegetation and reproduction with special reference to the tomato. Ore. Agr. Expt. Sta. Bul. 149. 1918.

KRAYBILL, H. R.

Effect of shading and ringing upon the chemical composition of apple and peach trees. New Hamp. Agr. Expt. Sta. Tech. Bul. 23. 1923.

MAGNESS, J. R.

The influence of summer pruning on bud development in the apple. Ore. Agr. Expt. Sta. Bul. 193. 1916.

POTTER, G. F. and H. R. KRAYBILL

Fruit spur composition in relation to fruit bud formation. Proc. Am. Soc. Hort. Sci. 1925:146-150.

ROBERTS, R. H.

Off-year apple bearing. Wis. Agr. Expt. Sta. Bul. 317. 1920.

Apple physiology. Wis. Agr. Expt. Sta. Res. Bul. 68. 1926.

SHOEMAKER, J. S.

The significance of chromosome studies in fruit breeding. Sci. Agr. 6:47-49. 1925.

THE INHERITANCE OF A QUANTITATIVE CHARACTER, LENGTH OF RACHILLA, IN AN OAT CROSS*¹

T. E. ODLAND

Associate Professor of Agronomy

The inheritance of quantitative characters such as yield, size of plant and others of like nature has been much less extensively studied than has the inheritance of qualitative characters. The reason is found largely in the fact that size characters are usually much less easily analyzed and often present rather complex problems. Quantitative characters are often so influenced by environmental conditions that genetic differences are obscured. A number of workers have, however, demonstrated that the inheritance of size characters may be explained on a factorial basis similar to that of the inheritance of qualitative characters. Sax,** Lindstrom,*** and others have pointed out the desirability of attempting to correlate size characters with easily recognized qualitative characters and thus facilitate the analysis of the former in any inheritance study.

A quantitative character that is relatively stable under varying environmental conditions is obviously very desirable for making a study of the nature of size inheritance. In the present study the size character chosen, length of rachilla in oats, seemed to offer an exceptionally stable character and one that could be studied in relation with a number of definite qualitative characters.

The material for the study reported in the present paper was obtained by making a cross between Early Gothland (*Avena sativa*) and Garton 784 (*Avena sativa orientalis*).

*This paper reports on one phase of a study in oat inheritance which was made by the author. The complete study will be reported in another publication.

**Genetics 8:522-560. 1923.

***Science 60:182-183. 1924.

¹Approved for publication as paper No. 46 by the Dean and Director, W. Va. Agr. Exp. Station.

The Early Gothland parent has a pubescent rachilla approximately 2.7 millimeters long on its lower grain while in the Gar-ton 784 parent the rachilla is extremely short, being approximately 1.6 millimeters long. It is free from pubescence except for an occasional hair. These two parents also differed in several other characters that were studied but the inheritance of these characters will not be considered in this paper.

The reciprocal crosses were made in 1922. The first F_1 generation was grown in the greenhouse during the winter of 1922-23. In the following five years F_1 , F_2 , F_3 , and F_4 generations were grown in field plots. Parental material was grown each year for comparison with the hybrid material. All material was grown in rows five feet long and spaced one foot apart. Twenty seeds were planted per row. The F_3 families from which it was planned to get rachilla measurements were all planted in five-row plots except in a few instances where there was not enough seed available.

The rachilla measurements were made by means of a pair of proportional dividers using a ratio of 10 to 1 and reading the measurements on a millimeter scale. The units in which the measurements are reported are in terms of .1 millimeter. A mounted reading glass was used to facilitate making the readings.

A sample of five grains from each plant was used for determining the length of rachilla for that particular plant. The number of grains to use as a representative sample was arrived at after a study of the variability of the length of rachilla had been made and a number of various sized samples ranging from three to fifteen grains from each plant had been compared. In a similar way it was determined to make measurements on fifty plants of each F_3 or F_4 family grown in order to determine the length of rachilla and its variability for that family.

In order to study the effect of the productivity of the soil on the length of rachilla a plot of each parent was planted on

both rich and poor soil in 1923. In both cases there was only a very slight increase in the length of rachilla on the rich soil although the yields were practically double and the height of the plants was about one-third greater on the rich ground. These facts indicated that the length of rachilla is a very stable character and little influenced by soil conditions.

The mode of inheritance of length of rachilla was studied by making measurements of the hybrid material as described, computing statistical constants, and analyzing the data from a biometrical standpoint. In this cross no significant difference was found between the reciprocal crosses in the inheritance of length of rachilla or in any of the other characters studied. In the tabulations the two crosses are therefore combined.

A summary of the results obtained in the three years 1923, 1924 and 1925, are presented in Table I.

The data show that the length of rachilla varied only slightly in the different years both in the parents and the F_2 populations. In all three years the F_1 plants showed a rachilla length which was approximately intermediate between the parents. The F_2 population ranged between the two parents although in no year were plants obtained with rachillas reaching the extremes of the parents.

The variation in length of rachilla from parent to parent in the F_2 with the mean of the population approximately midway between them and also a gradual falling off in numbers in the classes from the mid point to the two extremes, suggests that the inheritance of the length of rachilla can probably be best explained on a multiple factor basis.

If the factors concerned in the inheritance of this character were of equal value and had a cumulative effect a normal frequency curve would be expected in plotting any F_2 distribution. As may be seen from Table I, the type of curve obtained in plotting the F_2 distribution obtained in any year shows a considerable variation from a normal frequency curve. Skew curves such as the ones obtained suggest that the factors in-

TABLE 1.—Statistical constants for length of rachilla of the parents, F₁ and F₂ of the cross Early Gotland by Carton 784 and reciprocal.

Material or Generation	Year	Classes for Length of Rachilla in Units of .1 mm.																				Σ f	Means	Standard Deviation	Coefficient of Variability	
		14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33					
E. G.	1923												4	15	61	72	74	42	16	8	2	1	295	27.512±0.060	1.518±0.042	5.52±0.15
E. G.	1924											6	19	58	88	82	61	32	3	2	1		352	26.608±0.054	1.513±0.038	5.69±0.14
E. G.	1925													45	223	422	173	18	1				882	26.885±0.019	0.855±0.014	3.18±0.05
G. 784	1923		14	114	88	36	14	2															268	16.731±0.040	0.986±0.029	5.89±0.17
G. 784	1924	1	67	152	63	16	2	1															302	16.119±0.034	0.868±0.024	5.38±0.15
G. 784	1925	1	117	497	253	24	2																894	16.210±0.016	0.708±0.011	4.37±0.07
F ₁	1923							1	4	2													7	20.143		
F ₁	1924								2	5	1	1											9	21.111		
F ₁	1925									1	3	2	1										7	20.429		
F ₂	1923			2	3	16	25	49	62	42	35	27	18	6	4	0	0	1					290	21.548±0.087	2.191±0.061	10.17±0.29
F ₂	1924			4	12	32	71	86	99	92	54	43	24	8	3	1							529	21.185±0.062	2.116±0.044	9.99±0.21
F ₂	1925			2	7	19	57	97	93	87	47	16	8	0	3								436	20.938±0.056	1.734±0.040	8.28±0.19

volved are either of unequal value in determining the length of rachilla or are modified by factors of unequal value.

BREEDING BEHAVIOR OF F_3 PROGENIES FOR LENGTH OF RACHILLA

Sixty F_2 plants were continued into F_3 families in order to test their breeding behavior. The F_2 plants chosen for testing in F_3 were taken from various classes for length of rachilla, the number from each class being in approximate proportion to the total number of F_2 plants in any particular class. The correlation coefficient between the length of the rachilla in the F_2 parent and the mean of the F_3 family was found to be 0.886 ± 0.019 . This indicates that length of rachilla is an exceptionally stable size character and that the F_2 gives a good indication of what may be expected from the F_3 progeny from any plant.

The coefficient of variability was used as a criterion for determining which F_3 families were breeding true for certain rachilla lengths and which families appeared to be heterozygous for the factors determining this character. In Table II a frequency distribution has been made of the coefficients of variability and of mean length of rachilla for the different F_3 families grown in 1925. One of the F_3 families grown segregated for false wild oats and is not therefore included in this table.

If the highest coefficient for the parental material (5.01 ± 0.34) grown the same year is taken as marking the upper limit of variability expected in all lines homozygous for a certain length of rachilla, we find that there is one family breeding true for a rachilla length of 17, three for 21, one for 22, one for 24, one for 25 and one for 26. Apparently one family has been recovered breeding true for approximately the same length of rachilla as the Garton 784 parent and also one with a rachilla approximately as long as the Early Gothland parent. Between these extremes there are on this basis six other families breeding true for intermediate lengths. If a three factor

TABLE II. VARIABILITY IN LENGTH OF RACHILLA IN THE F_3 PROGENIES GROUPED BY CLASSES FOR LENGTH OF RACHILLA.

Mean Length of Rachilla in units of .1 mm.	Classes for Coefficient of Variability of the F_3 Progenies											Total No.
	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	
17	1			1								2
18								2	1	1	3	7
19				1				1	1		1	4
20				1	2		1	1	2	1		8
21			3	1		1	1	3	2	1	1	13
22	1			3	5	1	1		2			13
23				1	2	1						4
24			1	1	1	1		1				5
25		1										1
26		1		1								2
Totals	2	2	4	10	10	4	3	8	8	3	5	59

difference with all factors of equal value be assumed it would be expected to recover one family breeding true for each extreme and six intermediate homozygous families in a random sample of 64 individuals. The distribution of the homozygous families among the various intermediate classes for length of rachilla is not in very close agreement with what would be expected on such a three factor basis. The F_3 breeding behavior supports the theory that the inheritance of length of rachilla may be put on a multiple factor basis and also that the factors concerned are either not of equal value or are modified by factors of unequal value.

In 1926 F_4 families were grown from plants chosen from each F_3 family which was apparently homozygous as well as from a number of other F_3 families chosen at random. In each case families that appeared to be homozygous in the F_3 were found to be breeding true for a certain rachilla length in the F_4 .

TABLE III.—Length of rachilla in the pubescent and smooth rachilla segregates in the F₂ generations and the mean length of rachilla in the F₂ progenies breeding true for pubescent rachilla, segregating, and breeding true for smooth rachilla.

Character of Pubescence	Generation	Year	Classes for Length of Rachilla in Units of .1 mm.																			Total No	Means	Difference	Diff. in %
			16	17	18	19	20	21	22	23	24	25	26	27	28	29	30								
Smooth	2	1923	2	3	16	25	48	48	26	25	18	12	2						225	21.089±0.091					
Hairy	2	1923					1	14	16	10	9	6	4	4			1		65	23.138±0.168	2.049±0.191	10.7			
Smooth	2	1924	4	11	29	66	73	74	54	25	10	6	3					355	20.485±0.066						
Hairy	2	1924	1	3	5	13	25	38	29	33	18	5	3	1				174	22.615±0.098	2.130±0.118	18.0				
Smooth	2	1925	2	6	18	53	85	73	56	29	6	3						331	20.592±0.058						
Hairy	2	1925	1	1	4	12	20	31	18	10	5	3						105	22.029±0.115	1.437±0.129	11.1				
Smooth	3	1925		2	3	2	3		3	1								14	19.643±0.345	2.957±0.447*	6.6				
Segregating	3	1925			4	2	4	9	8	3	1							31	21.065±0.226	1.422±0.412**	3.4				
Hairy	3	1925					1	4	3	3	2	1	1					15	22.600±0.284	1.535±0.363†	4.2				

*Between hairy and smooth rachilla progenies.

**Between smooth and segregating progenies.

†Between hairy and segregating progenies.

Some of the other F_4 families appeared to be homozygous also while others were heterozygous. The F_4 material therefore substantiated the conclusions drawn from the study of the previous generations.

The length of rachilla seemed to be closely associated in inheritance with pubescence of the rachilla. The length of rachilla in the F_2 and F_3 material grown in 1925 grouped as to rachilla pubescence is shown in Table III.

The data show that in both the F_2 individuals and the F_3 families the hairy condition is closely associated with the longer rachillas. Analysis of the various F_2 populations grown and also of the F_3 progenies showed that undoubtedly the character for pubescence is due to a single factor difference. It seems logical therefore to conclude that the factor determining the inheritance of pubescence of rachilla is in the same linkage group as one or more of the factors determining the length of rachilla. No linkage was found between any of the other qualitative characters studied and length of rachilla.

GEOLOGY FROM MORGANTOWN TO CASCADE, WEST VIRGINIA, ALONG STATE ROUTE NUMBER 7*

JOHN L. TILTON

Professor of Geology, West Virginia University

CONTENTS

Introduction and Acknowledgements
Near Morgantown, West Virginia
The Conemaugh Series
Near Dellslow
The Allegheny Series
The Pottsville Series
Near Sturgis
Near Greer
The Section at Greer
The Mauch Chunk Series
The Greenbrier Series
The Pocono Series
Near Cascade

INTRODUCTION AND ACKNOWLEDGMENTS

It is the purpose of the present paper to describe the geologic conditions as seen along the new road from Morgantown to Cascade, West Virginia, in the valley of Deckers Creek, a stream that has barely been able as a master stream to maintain its course across Chestnut Ridge and erode the gorge in which stream, railroad and highway now lie.

The writer wishes to acknowledge the advice of Mr. David B. Reger of the West Virginia Geological Survey, whose extensive work on the Mississippian** will be evident in his report on Mercer, Monroe and Summers counties and in other papers. He also wishes to acknowledge the helpfulness of Mr. E. W. Skagg, class of 1926, West Virginia University, who

*Project No. 146A and about a mile of No. 3272.

**The following references are found of value:—Stuart Weller: *Mississippian Brachiopoda*, Mono. 1, Ill. State Geol. Survey, 1914; *Geology of Hardin County*, Bull. No. 41, Ill. State Geol. Survey, 1920. F. B. Meek and A. G. Worthen: *Geological Survey of Illinois*, Vol. 3, 1868. Charles Butts: *Mississippian Series of Eastern Kentucky*, Kentucky Geol. Survey, Series 6, 1922; *Mississippian Series of Western Kentucky*, Kentucky Geol. Surv., 1918. Arthur McQ. Miller: *Geology of Kentucky*, Dept. of Geology and Forestry of Kentucky, Series 5, Bull. 2, 1919.

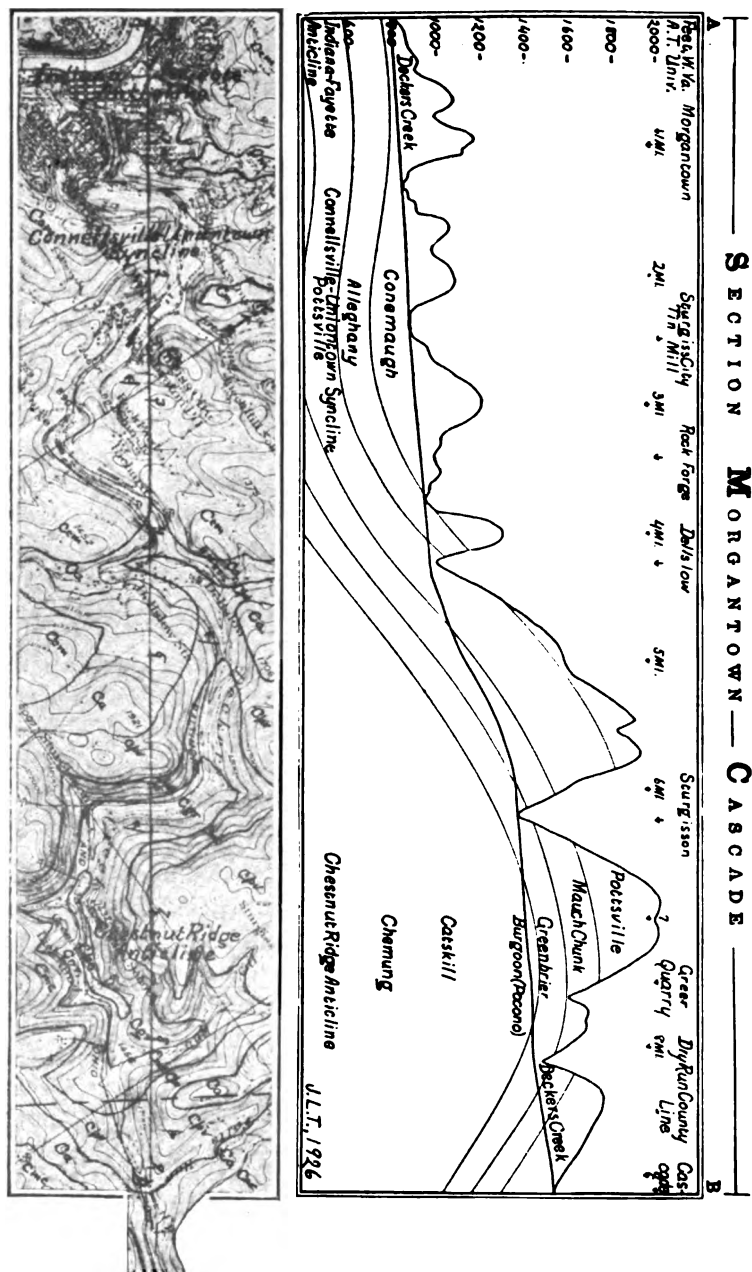


Fig. 1. Map and cross section from Morgantown to Cascade, W. Va.
The road follows Deckers Creek.

during the summer of 1926 constantly assisted in the collecting.

The report is published with the consent of Dr. I. C. White, State Geologist of West Virginia, with whose approval the work was undertaken, and later, before publication, with the consent of David B. Reger, who became Acting State Geologist following the death of Dr. White.

NEAR MORGANTOWN

The new highway leaves Morgantown at Valley Crossing. On the way at the Chestnut street bridge to Greenmont, it is well to note what lies along the railroad beneath, and the gorge that Deckers Creek has cut through the Buffalo sandstone.



Fig. 2. From one of the openings to the south along the high parts of Richwood avenue one gets a view of Greenmont and South Park on the left and of Deckers Creek on the right. Deckers Creek winds from the foreground out toward the new high school buildings in the center. The first bridge on the right is the Walnut street bridge to Greenmont connecting with the new road up Deckers Creek. The low terrace shows slightly along the creek. The chief terrace is that occupied by the main parts of Greenmont and South Park.

The railway leaves Morgantown close to the mouth of Deckers Creek, where the road turns sharply to the east beneath a high bluff of reddish gray Buffalo sandstone, which

continues in evidence past the Chestnut street bridge for a mile up the creek toward Sabraton. Across the creek to the south the lower terrace has been widened out for a ball field. At a higher level stands the Morgantown high school in a building area obtained by cutting into the shaly hillside and using the material to fill in the draw that crossed the locality. The flat above this level is a part of the main terrace to be traced along Monongahela river. A considerable portion of Morgantown is located upon it, including the post office and county court house. Of the three high bridges across Deckers Creek the second and third lie at the level of this terrace across the gorge that Deckers Creek has cut through the Buffalo sandstone. At the level of these bridges lie South Park and a portion of Greenmont, built on the gravels (Carmichael) that mark this main terrace. These gravels are a continuation of the gravels along the Monongahela, marking the former courses of streams in glacial and immediately postglacial time, so that the gorge that Deckers Creek has cut through the Buffalo sandstone, below the level of the terrace, is only post-glacial in age.

For the first three-fourths of a mile stream, railroad and highway all follow the cliff along the north side of the creek. Then, in another quarter of a mile toward Sabraton, the steepness of the hillside diminishes. This is because the sandstone strata now largely concealed are dipping to the southeast, bringing nearer to the level of the road the great beds of shale (Round Knob or Pittsburgh shale) which are more easily eroded than the sandstone, thus permitting a widening out of valleys. Near Valley Crossing is the high divide where that early geologist, J. J. Stevenson, collected fossils from the Ames limestone. Beyond Valley Crossing the Buffalo sandstone is beneath the level of the road. The Ames limestone now appears along the street and the car line about two-tenths of a mile to the north, at a cut in plain view by the roadside. Back of the hills to the north the slight dip of the strata to the southeast has brought the Pittsburgh coal below the level of the upland. From mines in this seam the coal is brought by

truck and by electric lines to the railroad and dumped into tipples. In the high ground to the north and east are the steep slopes around ledges of sandstone that cap the hills. That in view is the Lower Pittsburgh sandstone, immediately below the Pittsburgh coal. In places excavations in this high ground reveal the sandstone as the cause of the steepness near the hill-tops.

The Pittsburgh seam of coal itself and the heavy bed of sandstone above it belong to the Monongahela Series (Pennsylvanian System), only the base of which is thus seen near at hand. The complete Series may be seen along the roadway up Scotts Run. From the base of the Pittsburgh coal down to strata just below the level of Deckers Creek at its mouth the strata belong to what is called the Conemaugh Series, a condensed record of which follows, including beds of shale with the beds of sandstone named:—

THE CONEMAUGH SERIES*

	Feet
Sandstone (Lower Pittsburgh), etc.	47
Coal (Little Pittsburgh)	1
Sandstone (Connellsville), etc.	87
Coal (Little Clarksburg)	1
Sandstone (Lower Connellsville and Morgantown), etc.	117
Coal (Elk Lick)	2
Sandstone (Grafton), etc.	45
Limestone (Ames) and shale	28
Coal (Harlem)	2
Shale (including coprolite shale discovered by P. H. Price)	55
Sandstone (Saltsburg)	30
Coal (Bakerstown)	2
Sandstone (Buffalo), etc	102
Coal (Brush Creek)	1
Sandstone (Mahoning), etc.	65
Shale (Uffington)	5
Total	590

From the railroad station at Sabraton to beyond the tin plate mill, a distance of a mile, the terraces and broadened out

*West Virginia Geological Survey, Report on Marion, Monongalia and Taylor counties, p. 268-269.

valley in the shale have become a center of manufacturing and the location of homes.

Close to Sabraton railroad station lies the axis of the Connellsville-Uniontown syncline toward which the strata have been dipping. East of this axis the strata begin to rise again. The road lies diagonally to the direction of this rise for a mile beyond the tin mill at Sabraton P. O., in which stretch it has to pass over a hillside of shale whose tendency to slip has long been evident. Then we cross to the south side of the creek. As one approaches Rock Forge the strata seen at the mouth of Deckers Creek are again evident.

NEAR DELLSLOW

When the road swings off to the northeast toward Richard and Dellslow, strata not visible at the mouth of Deckers Creek become visible. Immediately are seen evidences of coal mining, for Upper Freeport coal lies just beneath the Uffington shale and the Upper Kittanning lies 96 feet below the Upper Freeport. Near Dellslow the beds of shaly Mahoning sandstone and of dark Uffington shale beneath, form the bluff to the north. Along this part of the road abandoned bee-hive coke ovens and silent top works at mines mark locations of former activity. At one place just west of Dellslow and north of the road a mine is still in operation. The succession of strata that rise between Rock Forge and Dellslow is known as the Allegheny Series, a condensed description of which is as follows:

THE ALLEGHENY SERIES*

Upper Freeport coal and shale	13.5
Fire clay, limestone and shale	59
Lower Freeport coal	1
Fire clay, shale and sandstone	36
Upper Kittanning coal and shale	1
Shale and sandstone	14
Middle Kittanning coal	1
Shale, sometimes with concretions of iron	20

*West Virginia Geological Survey, Report on Marion, Monongalia and Taylor counties, p. 236.

Lower Kitanning coal	4
Fire clay and shale with concretions of iron (concealed where section was made but found elsewhere)	57
Clarion coal	3
Fire clay	5
Total.....	214.5

At the bridge at Dellslow all the Allegheny Series has been eroded and another series of strata comes to light rising above the bed of the creek. This series, known as the Pottsville conglomerate, is much more resistant to stream action than are the Allegheny and Conemaugh Series. From Dellslow to the mouth of the creek at Morgantown the distance is 4.1 miles in a straight line, 5.8 miles along the bends of the creek. In this distance the fall is 200 feet. Above Dellslow the water tumbles around one great boulder after another, falling 300 feet in .7 mile. Near Dellslow the creek lays bare the Homewood and the Upper Connoquenessing divisions of the Pottsville, revealing an excellent foundation for a dam, a site



Fig. 3. Close to Dellslow an old dam 15 feet high is located on the Pottsville conglomerate (Upper Connoquenessing). A mill was formerly located on the right. In the center above the dam are marks of the road-cutting for the new highway. In the background the Pottsville conglomerate rises five hundred feet above the creek bed.



Fig. 4. Above Dellslow the water tumbles around one great boulder after another, falling 300 feet in .7 mile.

formerly utilized for a mill. The dam is still standing but the mill is gone.* The quantity of water is neither large nor constant, for the torrent of early spring becomes but a brook in late summer.

The subdivisions of the Pottsville are exposed along the roadway. The first ledge that rises steeply is the Homewood sandstone. The next conspicuous ledge close beneath it is the Upper Connoquenessing. Approximately at a shaly parting between the Homewood and the Upper Connoquenessing a valley comes in from the north (Tibbs Run). The shaly parting an eighth of a mile farther east separates the Lower Connoquenessing from the Sharon conglomerate. A condensed description of the Pottsville Series is as follows:—

THE POTTSVILLE SERIES**

Sandstone (Homewood)	50
Coal (Tionesta)	1
Fire clay, and shale with concretions of iron, traces of coal . . .	39

*Since the above was written the dam has been washed away.

**West Virginia Geological Survey, Report on Marion, Monongalia and Taylor Counties, p. 364.

Coal (Upper Mercer)	5
Shale and limestone	11
Coal (Lower Mercer)	1
Fire clay and shale	1
Sandstone (Upper Connoquenessing)	75
Coal (Quakertown)	2
Shale, sandy	15
Sandstone (Lower Connoquenessing)	60
Coal (Sharon)	Trace
Shale, sandy	15
Sandstone and conglomerate (Sharon)	25
Total	300

The road rises uniformly up the slope east of Dellslow on a bed of fragments wrenched partly by frost action from the steep walls and partly by blasting away the ledges. Below are great boulders in the bed of the stream, above are the steep slopes of sandstone and conglomerate rising 500 feet, and then, a little further east, rising 900 feet above the bed of the stream. The Upper Connoquenessing sandstone caps the knobs. The talus from the mountain side blocks the stream for several rods east of where the stream crosses the base of the Pottsville conglomerate, and along the road the split fragments of Sharon conglomerate reveal many fragments of plant fossils, impressions left in the sandstone.

In describing the Greenbrier and Mauch Chunk it is thought best to letter the various strata in the section at Greer quarry and use these letters in the local correlations. This is because the names of the shales and sandstones are under consideration and the local data hardly furnish grounds for final decision. In the description of the section at Greer the probable names are given as suggested by D. B. Reger, who is including the section among several studied in various parts of the state in preparation of a report on the Mississippian of the state. The fossils that are mentioned in this present paper agree with this correlation by Reger except that in the basal limestone (Fredonia?) no *Pugnoides ottumwa* has yet been

found, nor any specimen of *Platycrinus penicillus*. What the absence of these two index fossils means remains to be worked out. The gritty, cross-bedded material seems to have ground up within it nearly all evidence of life.

About half a mile further on up the roadway, 1.2 miles from the bridge at Dellslow and in a southeast direction, which is directly up the dip, one passes over the topmost beds of the Mauch Chunk Series, here concealed in the side ravine and in the hillside, and comes soon upon a cutting into the beds that lie next and immediately above the Greenbrier limestone. Here the top of the Greenbrier rises 15 feet above the roadway. About a foot above the top of the Greenbrier is a 3-inch bed of sandstone. Two feet above this sandstone is a fossiliferous horizon from which were collected *Zaphrentis spinulosa*, *Productus ovatus*, *Diaphragmus elegans*, *Orthotetes kaskaskiensis*, *Spirifer pellaensis*, *Composita subquadrata*, and a *Bellerophon*. Three feet above this, or 60 inches above the Greenbrier limestone, is the *Allorisma clavata* zone, the (g) zone at Greer quarry. This conspicuous zone is 30 inches above the Greenbrier at Greer. Further on up the side of the cut may be detected the weathered bluish (h) limestone, here not especially fossiliferous. The strata above are not well exposed. Here may be seen by the side of the road the iron pipe that drains a well reported as a "dry hole" 600-800 feet deep. No oil and gas were found, but there is a flowing well of mineral water that has been going to waste for years. The well itself is located near the center of the roadway, and drained to the side of the road by a six-inch pipe.

NEAR STURGISSON

Another half mile past the mouth of a small run where detritus conceals all, brings one to a second outcrop of limestone, the dip of which makes it pass beneath the first bed seen. This second limestone is (b), the basal bed of the Greenbrier at Greer, with the reddish (c) sandstone and shale above it. Here the roadway curves to the southwest toward Sturgisson, near which the Greenbrier limestone first seen

again comes into view above the (c) sandstone and shale. In this stretch of about a mile the direction of the road is very nearly that of the strike of the region, along which the outcrop of strata is about horizontal.

Across the creek and the track at Sturgisson this upper (e, f) Greenbrier limestone may be seen in an old quarry. Immediately above it is the dark streak of the (g) shale full of *Allorisma clavata*. Then comes the (h) limestone. Above this may be seen the red and green (i) shales, and then above these, a weathered (j) bed. The reddish beds (c) that are so conspicuous ten to thirty feet above the level of the roadway opposite Sturgisson, pass beneath the limestone that is in the face of this old quarry, and are not there visible.

At Sturgisson also may be seen the old 650-foot incline of the gravity railway down which Upper Connoquenessing sandstone was formerly transported to a mill where it was crushed and washed, then shipped as glass sand. The lowest ledge up this tramway is, of course, the Sharon, then the Lower Connoquenessing, then the Upper Connoquenessing which is the main quarry stone, and then possibly some of the Homewood. Fossils of *Lepidodendron* and of indefinite sticks and leaf-like impressions are noted especially in fragments of rock near the top of the Sharon, and again near the top of the Lower Connoquenessing. In another old quarry in the next lobe of the same hill half a mile east fragments of plant fossils still lie scattered over the floor of the quarry too poor in silica and too rich in iron to be acceptable for glass sand, but abundant evidence of forms existing when their fragments were washed into the bays and covered with sand. The quarry at present worked is a quarter of a mile east of this old quarry, and in the eastern lobe of this same hill.

At Sturgisson the new road in turning southeast cuts through the end of a low divide, revealing a good exposure of the topmost beds of the lowest division (b) of the Greenbrier, with thirty feet of the reddish sandstone and shale (c) ex-

tending up to the base of the lowest limestone (d) quarried at Greer. From here to Greer the direction of the road is in general up the dip of the west limb of the Chestnut Ridge anticline. The road remains at the level of the lowest division (b) to a point .8 mile east of Greer. This lowest limestone is a cross-bedded siliceous limestone, apparently not fossiliferous, but near the top of it along the old road from Greer to the quarry and at a point a few yards east of the crusher a few minute gastropods and fragments of crinoid stems were detected. The fresh surface of the cuts along the road were scanned in vain for any evidence of life, though a rather extended list of fossils is recorded from the southern part of the state, from Western Kentucky, from Illinois and Ohio.

The base of the (b) limestone may be seen at a sharp turn in the road that goes southwest up the hill opposite Sturgisson school, at a point only a few yards from the railroad. Here, as one goes west toward the angle in the road, the top bed of cross-bedded Pocono sandstone appears by the road side. At the angle of the road the shaly portion of the bottom of the (b) limestone has been dug away, revealing old mud cracks in the bottom beds of the limestone. The top of the Pocono first appears in the stream bed about half a mile upstream from Sturgisson and then appears at various levels along the railroad toward Greer. The creek has cut down three to four feet into the uneven surface of it at the railroad bridge west of the mill on the branch line to the quarry, and also at the foot bridge near the mill. Near the mill the road bed ten feet above the bed of the creek is in the basal (b) limestone of the Greenbrier with no Pocono sandstone there visible. This uneven surface of the Pocono marks a discontinuity, in which gap fully seventeen hundred feet of strata are reported by Reger present in the southern part of the state but absent here. On depression of this eroded land surface the first deposit locally was the calcareous mud seen at the angle in the road south of Sturgisson school, then, on complete subsidence, the cross-bedded siliceous (b) limestone was laid down.

NEAR GREER

The Greer quarry is likely to remain an important quarry and an important geologic exhibit for many years to come. It is the best located limestone quarry in the region tributary to Monongahela river in West Virginia, supplies a large amount of excellent limestone for land purposes and for road work, and may in the future add cement to its output. When the overburden becomes excessive as the quarry is worked further back into the hill the quarry can be worked as an underground mine, by room and pillar method instead of by stripping.



Fig. 5. From the hillside just south of the railroad station at Greer one gets a view across the valley to the mill in the center, then to the crusher beyond. The basal limestone (b) is concealed by the mill but appears to the right and left of it. In the distance on the right is the main quarry face (e, f), with the Mauch Chunk rising above as a separate unit. Other beds of the Mauch Chunk are concealed amid the trees, and in the background the Pottsville conglomerate forms a heavy capping, the great ledges of which lie with yawning chasms along the crest.

A part of the old road from the mill to the quarry has been cut away in the construction of the new highway, but a footpath a little to the east leads back into the old road. Above the basal limestone (b), which here forms the cliff along the highway past the mill, is the (c) reddish shale and



Fig. 6. The gritty, cross-bedded, basal member (b) of the Greenbrier limestone formed a cliff right where the road now lies close to the mill at Greer.

sandstone. Looking back across the valley toward the railroad station the (c) shale and sandstone also appear by the track both east and west of the depot. Above the (c) shale and sandstone in the old road to the quarry appears the 20-foot basal ledge (d). Back of the crusher the following fossils have been found in this bed: *Campophyllum gasperense*, *Zaphrentis spinulifera*, crinoid stems, *Fenestella*, *Diaphragmus elegans*, *Spirifer pellaensis*, *Composita trinuclea*, *Bulimorpha*, *Euomphalus*, other Gastropoda two species, Cephalopoda (young stage), *Griffithides* sp.

About eight feet above the level of the tramway where the crusher is fed in a conspicuous crinoidal layer that can be traced along the face of the quarry to the eastern side of the projection where the weathered surface has revealed *Pentremites pyramidalis*. Here and there throughout the quarry may be seen *Zaphrentis spinulosa*, *Campophyllum gasperense*, crinoid stems, *Pterotocrinus menardensis*, *Productus ovatus*, *Diaphragmus elegans*, *Orthotetes keokuk*, *Spirifer pellaensis*, *Composita trinuclea*, *Martinia*, *Bellerophon* and *Griffithides*.

Of these the crinoid stems, *Productus ovatus* and *Diaphragmus elegans* are very abundant.

It has not yet been found possible to subdivide this mass of limestone 47 feet thick forming at present the face of the quarry into subdivisions corresponding to those found further south. The Glen Dean (Alderson), which D. B. Reger reports present in the southern part of the state but thinning out northward, has not been recognized here. The Greer quarries are, however, covered by the same horizons here in the northern part of the state that are reported present in the southern part of the state and farther west. The change in physical conditions of deposition from that in which the uppermost Greenbrier limestone was laid down to that in which the lowest Mauch Chunk (g) shales above were laid down is indeed very great, and seems to mark a non-evident disconformity, during which interval of time represented by the disconformity the Glen Dean (Alderson) and Cypress beds were laid down in the southern part of the state while in the northern part of the state there was a low-lying land near the shore. In the later calcareous beds of the Mauch Chunk may also be found some of the kinds of fossils that occur in the uppermost Greenbrier limestone below. It should be noted, however, that there are differences. The *Composita* present in the Greenbrier limestone is narrower than that found in the Mauch Chunk limestone above, though in a large collection variations of each toward the other may be found. This may be expressed in the saying that in the Greenbrier the forms center in *Composita trinuclea*, while in limestones of the Mauch Chunk above the forms center in *Composita subquadrata*. In the Greenbrier limestone below, corals, crinoids, *Productus ovatus*, *Diaphragmus elegans* and *Orthotetes keokuk* are common, while in the Mauch Chunk *Orthotetes kaskaskiensis*, *Composita subquadrata*, *Aviculopecten* and *Myalina* are found in the limestones as well as in the shales.

The overburden at the quarry is unfortunate for the process of quarrying but it is very advantageous for the study of



Fig. 7. The main face of the quarry as it is at present (1926) consists of 47 feet of Greenbrier limestone (e, f), above which extends 83 feet of Mauch Chunk (g-t) that is visible. The floor of the quarry is the lower (d) 20-foot bed of Greenbrier limestone. Thus the quarry limestone is here 67 feet thick.

the strata. All the strata appearing above the quarry face are classified with the Mauch Chunk. Thirty inches above the quarry limestone is about a foot of dark shale rich in *Allorisma clavata*, a distinct fossil horizon. Here also are to be found *Orbiculoidea*, *Lingula*, *Orthotetes kaskaskiensis*, *Spirifer pellaensis*, *Composita subquadrata*, *Myalina elongata*, *Aviculopecten*, *Edmondia*, *Schizodus* and *Gastropoda*. At the point where search was made for sandstone immediately above the limestone no evidence of it was found.

There is a bluish limestone (h) above the dark shale (g). Here were collected *Productus ovatus*, *Composita subquadrata*, *Spirifer pellaensis*, *Sulcatopinna missouriensis* and *Allorisma clavata*.

Between the top of the dense bluish limestone (h) and a foot of decomposed fossiliferous limestone (j) lies 13 feet of shale (i), which appears to be red where oxidized on the surface, but beneath the surface the shale is green, under the re-

ducing effect of lime from the limestone above. *Allorisma clavata* is found near the base of this shale.

The next 32 feet 10 in. are the limestone and shale lettered (j, k, l, m). In the lowest decomposed bluish limestone (j) about a foot thick are to be found *Productus ovatus*, *Orthotetes kaskaskiensis*, *Pustula*, *Spirifer pellaensis*, *Composita subquadrata*, *Aviculopecten*. In the five feet of shale (k) between this and the next decomposed bluish limestone are to be found *Edmondia* (abundant), *Allorisma clavata*, *Aviculopecten*, and another pelecypod whose genus was not determined. The second decomposing limestone (l), also a foot thick, is fossiliferous. Here are found *Productus ovatus*, *Orthotetes kaskaskiensis* and *Spirifer pellaensis*. These are also found in the lowest portion of the 17 feet of dark shale (m) next above, beneath the 8-foot bluish limestone (n) that forms the conspicuous ledge along the hillside. This thick limestone is not especially fossiliferous.

Immediately above the 8-foot bed of bluish limestone near the top of the cliff are three fossiliferous horizons the first two of which are classed with the beds below already mentioned. The first of these (o), a shale six inches thick, contains *Leda*, *Aviculopecten*, *Allorisma* and *Sphenotus*. It is an *Aviculopecten* horizon. The second (p), immediately above this shale, is a four-inch bed of dark limestone, in which are found parallel-veined leaf-like impressions (algae), *Martinia sulcata*, *Euomphalus*, *Bellerophon*, *Edmondia* and *Ostracoda*.

The contrast between the faunules of the lowest (j) and of the highest (p) beds is very striking. In the lowest beds *Orthotetes*, *Productus*, *Spirifer* and *Composita* are abundant. It is an *Orthotetes* horizon. *Aviculopecten* is present but is not abundant. It is a brachiopod faunule. In the upper beds *Aviculopecten* occurs in great numbers along with other pelecypods and gastropods. It is a pelecypod horizon, and the topmost beds an *Aviculopecten* horizon. In the corresponding shale at the spring above the crusher the *Aviculopecten*

horizon is evident in the shale, together with *Leda bellistriata*, *Crania*, *Lingula* and *Allorisma*. Here a thin limestone in the midst of the shale contains an abundance of *Composita subquadrata*, along with *Productus ovatus* and *Orthotetes kaskiensis*.

The six-foot dark shale (q) next above the thin limestone contains *Leda bellistriata* and a *Myalina*. It is a *Leda* horizon. Immediately above the six-foot bed of shale just mentioned is a five-inch bed of micaceous sandstone (r), followed by a six-foot mass of shale (s). Exactly how far the shale continues up to a ledge of sandstone is not here evident, but the estimate here used is nine feet, the interval found at the spring above the crusher.

The thickness of the sandstone (t) above the shale is also not evident, but weathered grayish fragments and small portions of thin sandstone in place are noted at intervals far up the hillside. From there on fragments of white Pottsville conglomerate and sandstone, like that which forms a ledge at the top of the hill, are frequently seen. The top of the hill .8 mile north of the quarry is at 2200 feet A. T. (Upper Connoquenesing?), and the bench in the hill just above the quarry is at 1800 feet A. T., a difference of 400 feet.

THE SECTION AT GREER QUARRY*

	Feet	Inches
Mississippian System.		
Mauch Chunk Series.		
(t) (Droop)		
Sandstone, gray and light brown, medium grained,		
base not exposed	?	
(Ada) (21 ft. 5 in.)		
Shale, top not exposed	9	
(s) Shale, dark, clayey	6	
(r) Sandstone, brownish, fine grained, micaceous		5
(q) Shale, dark, fossiliferous at base, <i>Leda</i> zone	6	
(Reynolds): (32 ft. 10 in.)		
(p) Limestone, dark, fossiliferous		4
(o) Shale, dark, fossiliferous, <i>Aviculopecten</i> zone . .		6

*See statement on page 73.

(n)	Limestone, bluish, not especially fossiliferous . . .	8
(m)	Shale, dark, not especially fossiliferous	17
(l)	Limestone, dark, decomposed, fossiliferous	1
(k)	Shale, gray, fossiliferous	5
(j)	Limestone, dark, decomposed, fossiliferous, Orthotetes zone	1
(i)	(Bickett shale): (13 ft.) Shale, greenish and red, clayey, somewhat fossiliferous at base	13
(h)	(Glenray): (10 ft.) Limestone, bluish, dense, fossiliferous at base . . .	10
(g)	(Lillydale): (6 ft.) Shale, dark clayey, fossiliferous, <i>Allorisma clavata</i> zone	6
Greenbrier Series:		
	(Casper): (87 ft.)	
(f)	Limestone, dark gray, quarry face, fossiliferous,	
(e)	crinoidal layer about a third way up from the base	67
(d)	Limestone, dark, fossiliferous; base of quarry . .	20
	(Bethel): (30 ft.)	
(c)	Shale and sandstone, reddish	30
	(Fredonia): (28 ft.)	
(b)	Limestone, light gray, siliceous, cross-bedded . .	28
	(Base of Greenbrier Series)	
Pocono Series.		
	(Burgoon)	
(a)	Sandstone, brownish gray, coarse, about 3 ft. exposed, 4½ ft. allowed	4 6
	(Bed of Deckers Creek at 1442 ft. A. T.)	
Total to top of excavation		232 9
(Total to top of hill, 758 ft.)		

Half a mile to the east of Greer quarry the roadway again cuts into basal limestone (b) of the Greenbrier and the overlying reddish sandstone and shale (c). Here at a level five feet above the top of the basal limestone is an impure brownish limestone in the reddish sandstone and shale (c) rich in *Productus ovatus*, nearly all of which are crushed. Here are also found crinoid stems, *Composita trinuclea*, *Myalina*, and *Bellerophon*.

At this point, half a mile east of Greer quarry, the strata

dip $5\frac{1}{2}^{\circ}$ NW., revealing the presence of a small syncline a little to the west. The dip soon changes to the southeast, the general direction of dip for this limb of the Chestnut Ridge anticline. A minor variation in dip was also noted in the west limb of the anticline about three-quarters of a mile northeast of Sturgis.



Fig. 8. About half a mile east of Greer quarries the reddish sandstone and shale (c) is cut away and the upper two feet of the limestone below. The rest of the limestone forms a bench extending out to the left. The fossil horizon is located where the man is at work.

The Pocono sandstone was mentioned as appearing above the creek bed half a mile above Sturgis and just west of Silica Glass Plant. It disappears beneath the creek bed about half a mile above Greer quarry.

Just east of the Preston-Monongalia county line the change in dip of the beds and the rapid rise of the creek bed are such that the various beds of the Greenbrier and Mauch Chunk all disappear beneath the creek bed in a short distance, and Deckers Creek is found cascading over the heavy sandstone beds of the descending Pottsville Series. From Sturgis to the Preston-Monongalia county line, a distance of 2.3 miles in a straight line, 2.35 miles in the nearly straight water



Fig. 9. Near Cascade Deckers Creek flows over the Upper Connoquenesing and other Pottsville sandstones in a series of cascades.

course, the fall is 100 feet. From the county line to Cascade, a distance of but 0.7 mile in a straight line, 0.87 mile as the water flows, the fall is 157 feet, over the successive ledges of the Pottsville.

NEAR CASCADE

Crossing Dry Run the highway in a somewhat steep but uniform grade mounts the side of the lowest beds (Sharon) of the Pottsville. In this half mile the broken masses of rock along the roadside contain the remains of many fragments of plants, some of which are simply irregular fragments of logs lying crosswise as they were washed in with the sand. Other fragments have broad parallel-veined leaf-like impressions. All are impressions, none of the original material of woody tissue is preserved. The Pottsville sandstone and conglomerate here rises to a height of 2100 feet A. T. just west of Falls Run, a height of 620 feet above the creek bed. On the side of this mass two quarries have been opened, from which the rock is transported to a crusher and washing plant near at hand. Where the Pottsville disappears beneath the stream bed at Cascade a low dam has been erected to empound the



Fig. 10.—Just below Cascade two quarries have been opened in the Upper Connoquenessing sandstone. Here the beds may be seen dipping southeast toward Cascade.

water for use at a power plant whose tall chimney rises near by. Farther east the descending beds of the Allegheny and Conemaugh Series appear in turn where not eroded, and various seams of coal belonging to these Series are mined along the valley sides.

ABSTRACTS

The following is a partial list of abstracts of papers published by members of the science faculties of West Virginia University since the publication of the last Bulletin of the Scientific Society. The abstracts are arranged alphabetically according to departments.

DEPARTMENT OF AGRONOMY AND GENETICS

DEATRICK, E. P. **Liming Dekalb silt loam.** (Being published as popular bulletin). Data on four yields of hay from plots one-half of which were limed is subjected to analysis by statistical methods and it is concluded that liming produces large increases in soybean and cowpea hay.

DEATRICK, E. P. **Apparatus for growing plants in soil under microbiologically controlled conditions.** Jour. Am. Soc. Agron., Vol. 20, No. 6, p. 643-645.) An apparatus is described for use in growing plants under microbiologically controlled conditions. The use of Livingston's auto-irrigator cones allows sub-surface watering wherein both the water and soil can be readily sterilized and be protected from contamination. After imbedding the cones, the soil is covered with a mulch of gravel of large size and this is covered with cotton and paper. A number of the pieces of standard apparatus can be used for protecting against contamination around the stem of the plants themselves.

ODLAND, T. E., and R. J. GARBER. **A drying house for the rapid handling of forage samples.** Jour. Am. Soc. Agron. 20: 1928. This is a description of a drying house that was designed by the authors and built on the Agronomy Farm. It has proved a solution for one of the most troublesome problems in connection with the handling of dry matter samples in forage crop investigations. The moisture content of the samples can be reduced down to between 1 and 3 per cent in from 24 to 48 hours. About 1000 samples can be handled at a time.

DEATRICK, E. P. **Porous clay auto-irrigator cones for watering potted soil and plants.** Jour. Am. Soc. Agron., 19(3):252-255. 1927. Potted soil is usually kept moistened by

pouring water on the surface of the soil. When the water content is a factor to be controlled, water is generally added to the soil while the pot is on the pan of a balance until the loss is restored and the potted soil is brought back to its original weight. This is laborious, and precludes the running of a large number of pots without special attendants. In the case of clay soils the surface soil very readily becomes hard following surface watering. The top layers become water logged and the distribution of water is not uniform. By imbedding Livingston's auto-irrigator (porous clay Erlenmeyer-shaped) cones into soil and connecting them with a water reservoir, water is drawn into the cones as the soil absorbs water out of them. The flow of water may be reduced by inserting mercury manometers in the water line. Thus, one hundred and fifty potted soils have been watered with a minimum of labor and with highly satisfactory results.

ODLAND, T. E. Cultural experiments with soybeans for silage and for hay. W. Va. Agr. Exp. Sta. Bul. 227. (In press). Corn and soybeans were grown both alone and in various combinations for silage. Soybeans were also grown alone at various rates and dates of planting for hay and in combination with Sudan grass, Sorghum, and Millet. When corn was grown alone for silage a stand of 3 stalks per hill or a stalk every 14 inches in the drilled row gave the most satisfactory results. No increase in tonnage per acre was obtained by growing soybeans with corn but the silage was higher in protein content. The soybeans reduced the yield of shelled corn about 7 bushels per acre. The increase in protein per acre due to the growing of the soybeans with corn was not large enough to compensate for the extra work necessary in growing the combination.

Soybeans grown alone yielded practically the same whether grown in cultivated rows or seeded solid. The soybeans in the cultivated rows had the higher protein content. Soybeans grown with corn did not increase the per cent of protein in the corn and neither did the corn have any influence on the protein content of the soybeans.

Soybeans produced the best results when planted at the rate of 6 to 8 pecks per acre and when seeded about May 20. Soybeans and Sudan grass made the best combination tested for hay purposes.

DEATRICK, E. P. **Reduction of nitrates in soil under soybeans.** *Jour. Am. Soc. Agron.*, Vol. 20 (9), 947-958. The nitrates in soil under soybeans at harvest time have been found to be very low. The planting of wheat immediately after the harvest of the soybeans does not allow the nitrates to increase. It is concluded from data collected that a period allowing considerable nitrification to take place between the time of harvest and that of seeding wheat is of the utmost importance.

GARBER, R. J., and K. S. QUISENBERRY. The inheritance of length of style in buckwheat. *Jour. Agric. Res.* 34(2): 181-183. 1927. Japanese and Silverhull buckwheat plants were self fertilized by covering flower clusters with glassine bags or by covering entire plants with muslin cages. The selfed seed obtained was planted and the style length of the progeny was compared with that of the parents. The Silverhull short style plant gave progeny consisting of 86 short style and 32 long style plants. Four Japanese short style plants produced 19 short style and 8 long style plants. In general, long style plants produced progeny with long style, though exceptions are noted. The authors conclude that style length is controlled by a single factor difference, short style being dominant to long style.

GARBER, R. J., and K. S. QUISENBERRY. Self fertilization in buckwheat. *Jour. Agric. Res.* 34(2):185-190. 1 fig. 1927. An experiment in buckwheat breeding reports the relative self fertility of different kinds of buckwheat as well as the best method of self-fertilization by artificial means. Varieties of *Fagopyrum tataricum* were much more highly self-fertile than varieties of *Fagopyrum esculentum*. Large glassine bags which enclosed one or more flower clusters or

muslin cages which enclosed the entire plant were found to be most satisfactory in obtaining selfed seed. Short-styled plants were found to be somewhat more self fertile than long-styled plants.

GARBER, R. J. What has been accomplished by breeding small grains? *Jour. Am. Soc. Agron.* 19(8):721-742. 1927. Agricultural practices of 75 years ago as given in the annual report of the United States Commissioner of Patents are briefly summarized. This summary points out important changes in the cultural practices during the last three quarters of a century. First hand information as to the present status of small grain breeding is obtained from questionnaires supplied by workers at different experiment stations in the United States and Canada. Statistical analysis of these data show, first, that there is a considerable part of the small grain area in the United States and Canada seeded to recently improved varieties, and second, that an appreciable increase in yield has been produced in certain regions during the last two decades by the dissemination of improved varieties. A second part of the questionnaire asked for information as to lines along which improvement of small grains is sought at present. These data vary largely with the region and crop reported. Most stations place greater yield, better quality, stiffer straw, winter hardiness, and resistance to disease as the improvements sought.

GARBER, R. J., and H. K. ROWLEY. A defective endosperm in the heterozygous condition as related to yield in maize. *Jour. Amer. Soc. Agron.* 19(9):797-803. 1927. A strain of Leaming corn which had been selfed for four and five years was used to test the effect of a certain defective endosperm in the heterozygous condition on yield. This character when homozygous has a profound influence on the growth of the plant. Heterozygous defective plants cannot be detected from the homozygous normal plants when growing in the field. The mean yield of the normal plants in 1925 was about one-third and in 1926 one-fourth more than the re-

spective mean yields of the heterozygous defective plants. No significant difference was found between the two kinds of plants with respect to height and number of nodes per plant.

GARBER, R. J., and K. S. QUISENBERRY. Natural crossing in oats at Morgantown, West Virginia. *Jour. Am. Soc. Agron.* 19(2):191-197. 1927. Data are presented to show the amount of natural crossing in oats at Morgantown during the years 1922, 1923, and 1924. Six varieties of *Avena sativa* and one variety of *Avena byzantina* were grown in rows 18 inches long and 1 foot apart. Each light seeded variety with an adjacent dark seeded form was grown in four systematically distributed triple row plots. Inheritance studies have shown that dark seed color in oats is dominant. An F_1 hybrid between a black seeded plant and a light seeded one may be detected on the basis of grain color among the progeny of the light seeded parent. The data presented show the extent of natural crossing to be relatively low. Varieties of *Avena sativa* show one natural cross during the three years with a total of 7742 plants examined, while an average of 0.41% based on 1708 plants was found between *A. byzantina* and *A. sativa*. Climatological data presented indicate that weather conditions may influence natural crossing in oats. Dry weather seems to increase whereas rainy weather seems to decrease the amount of natural crossing in oats. The authors suggest that the apparent instability of certain forms of *Avena byzantina* generally attributed to mutations may be caused in part by natural crossing.

GARBER, R. J., and M. M. HOOVER. Another instance of a chlorophyll mutation in maize. *Jour. of Hered.* Vol. 18(12):543. 1927. A striped plant appeared in one of the selfed strains of maize isolated from the Leaming variety at the Agronomy Farm, University of West Virginia, during the summer of 1925. The striping of this chimera was limited to one-half of the plant and was apparent in tassel glumes, leaves, and leaf sheaths. Plants produced by selfing this chimera were normal green. Open pollinated F_1 plants produced 209

normal green and 14 striped plants in 1927 which seem to indicate the variation is heritable and recessive.

GARBER, R. J., and M. M. HOOVER. The relation of smut infection to yield in maize. *Amer. Soc. Agron.*, Vol. 20(7):735-746.

Strains of maize which differed strikingly with respect to resistance to smut were isolated by self-fertilization. The susceptible lines of maize differed sharply also with respect to localization of smut infection, some were rather generally susceptible, others were predominantly susceptible in certain regions of the plant.

The greatest reduction in yield, owing to smut, among corn plants of the same genotype was brought about by barrenness of the host induced by the fungus. The barrenness among 1188 smut free plants from selfed lines was 19.8 per cent as compared with 38.0 per cent among 868 smutted plants from the same selfed lines, whereas the barrenness among 469 smut free F_1 plants was 0.6 per cent and among 531 similar F_1 plants infected with smut was 6.6 per cent.

In this investigation it has not been possible to demonstrate a significant decrease in yield owing to smut infection among corn plants of the same genotype other than that caused by barrenness of the host induced by the fungus. Corn plants infected with smut in the tassel only, yielded on the average more than did plants of similar genetic constitution but free from smut. This was demonstrated both in selfed lines and in F_1 crosses between selfed lines.

GARBER, R. J., GIDDINGS, N. J., and M. M. HOOVER. 1928. Breeding for disease resistance with particular reference to the smut of oats. *Scientific Agriculture*, Vol. IX(2):103-115.

GARBER, R. J. 1928. The nature and significance of mutations in present day breeding methods. *Scientific Agriculture*, Vol. IX(3):133-142.

ODLAND, T. E. **The inheritance of rachilla length and its relation to other characters in a cross between *Avena Sativa* and *Avena sativa orientalis*.** W. Va. Agr. Exp. Sta. Tech. Bul. 219. 1928. This was a study made of the inheritance of length of rachilla, ligule, panicle type, color, and pubescence of the rachilla in a cross between two varieties of oats, Early Gothland and Garton 784. The length of rachilla was found to be a very stable size character and was little influenced by environmental conditions.

The inheritance of length of rachilla was found to be conditioned by multiple factors. Homozygous families which bred true for various lengths of rachilla were obtained in the F_3 and F_4 generations. A close linkage was found between the factor for rachilla pubescence and at least one of the factors or groups of factors for length of rachilla. Rachilla pubescence was found to be inherited as a single factor difference.

The inheritance of ligule is due to duplicate factors in this cross and panicle type to a single factor difference. The presence of both factors for the liguleless condition prevents the factor for open panicle from functioning so that no open panicle, liguleless forms are obtained. In this cross the color of grain is due to a one factor difference.

ODLAND, T. E., and R. J. GARBER. **Size of plat and number of replications in field experiments with soybeans.** Jour. Am. Soc. Agron. 20:93-108. 1928. Two years' data were obtained with soybeans grown in cultivated rows and harvested in units so that plats of various sizes could be made up and the effect of size of plat on variability studied. The crop was harvested for forage one year and for seed the other year. The effect of replicating the 16-foot plats on the variability of the yields was also studied.

As the size of plot was increased from 8 to 112 feet of row the variability in yields was reduced continuously. The greatest reduction in variability occurred, as measured by the standard deviation, when the length of row was increased

from 8 feet to 16 feet. The results indicate that a row length of 16 feet will probably be the most satisfactory when both reliability of results and economy of land and labor are considered. The variability in yields of the 16-foot plats was reduced as the number of replications was increased from one to nine. It would seem, however, from the results obtained, that replicating three times will give sufficient accuracy in field tests under the conditions where these experiments were made.

DEPARTMENT OF CHEMISTRY

SOME CYCLOHEXYL-PHENOLS AND PHENOL ETHERS

J. F. BARTLETT and C. E. GARLAND

Journal of the American Chemical Society, 49, 2098 (1927).
Chemical Abstracts, 21, 3046.

(This article is an abstract of a thesis submitted by J. F. Bartlett, in partial fulfillment of the requirements for the degree of Master of Arts in Chemistry, at West Virginia University.)

Due to the recent developments in connection with the preparation and studies made of the germicidal properties of alkyl and aryl phenols, it was decided to prepare some of the cyclohexyl derivatives in order to compare their properties with those already known.

Cyclohexyl chloride was condensed with resorcinol anisole and phenetole, in the presence of anhydrous aluminum chloride, giving cyclohexyl-resorcinol, cyclohexyl-anisole, and cyclohexyl-phenetole. Cyclohexyl-phenol was prepared by the hydrolysis of cyclohexyl-anisole as well as by the condensation of phenol and cyclohexyl chloride in the presence of fused zinc chloride. A benzoyl ester of the cyclohexyl-phenol was obtained.

The phenol coefficient of the substituted resorcinol was determined by Dr. R. S. Spray, of the West Virginia University School of Medicine. The resorcinol derivative gave a value of 23-27 while the substituted phenol was too insoluble to indicate bactericidal action.

Physical properties of these compounds were determined. Cyclohexyl-resorcinol. $C_6H_3(C_6H_{11})_2(OH)_2$ (1, 2, 4).—m. p. 124-125°. Cyclohexyl-anisole. $C_6H_4(C_6H_{11})_2OCH_3$ (1, 4).—b. p. 146-148° (16 mm.); d_4^{20} , 1.0209; d_4^{25} , 1.0004; n_D^{25} , 1.5305; molecular refraction: calcd. 58.07, found: 58.71. Mol. wt. calcd. 190.14. Found: 184.8. Cyclohexyl-phenetole. $C_6H_4(C_6H_{11})_2OC_2H_5$ (1, 4).—b. p.

155-157° (16 mm.); n_D^{25} , 1.5262. Partly solidified on standing. Cyclohexyl-phenol. $C_6H_4(C_6H_{11})$. OH(1, 4).—m. p. 128°. Benzoyl ester of cyclohexyl-phenol, m. p., 114-114.5°.

Work in the field of cyclohexyl-phenols and derivatives is being continued.

DEPARTMENT OF CHEMISTRY
RHYTHMIC BANDS IN BARIUM SILCATE SACS¹

EARL C. H. DAVIES and H. B. JONES

Transparent sacs of barium silcate, grown in silicic acid gel, show sharp, rhythmic, translucent bands, accompanied by an accumulation of barium sulphate in the knife-blade, lower, cutting edges of the sacs. About 50 bands form in a 7 centimeter long sac which is about as wide as the test tube, hollow, open at the top, and thin or thick, depending upon the stiffness of the gel and osmotic strength and density of the barium chloride solution which is put upon the partially set gel. Formation of a 7 centimeter sac occurs in less than two days. Some of the shorter sacs have the appearance of closed sea shells, with the hinged side up. With softer gels and suitable concentration of barium chloride, sacs are shaped like a bladder and look so natural that one might almost believe that it really is a bladder of some small animal. Greater concentrations of barium chloride give highly convoluted sacs, with bands similar to the bands on the straight sacs. The four substances used in the experiment are: barium chloride, water, sulphuric acid, and water glass. Each of these has been varied while the others were kept constant, so that we know how variations affect the results. Preliminary experiments show that sacs of lead silicate may be grown in a somewhat similar manner.

¹Abstract of Paper for Physical Chemistry Section, Detroit Meeting, American Chemical Society. Week of September 5, 1927. (10 minutes).

RHYTHMIC DIURNAL BANDS OF GOLD AND PLATINUM IN SILICIC ACID GEL

E. C. H. DAVIES and VICTORIAN SILVERTZ

The Jour. of Phys. Chem., **30**, 1467-1476. (Nov. 1925)

1. Simulated, rhythmic, diurnal bands of red, colloidal gold were obtained in a silicic acid gel containing 10 cc. of 3N HCl, 10 cc. of water glass (d. = 1.16), 0.8 cc. of 1% gold chloride and 0.2 g. of oxalic acid, whenever exposure to light through a grid with rhythmic openings, was followed by several more days in the dark.

2. The system gold oxalate-silicic acid gel shows remarkably interesting photochemical after-effects when preliminary light exposure of different durations, not sufficient for visible reduction, is followed by 24 hours in the dark and then a second exposure.

3. Red, blue, or yellow gold was made in different tubes of gel of identical composition but of different age when exposed to light. Freshly prepared gel gave red gold, and older gel gave blue gold and a still older gel gave yellow gold.

4. Reduction to the red gold is more rapid in the gel than in the same mixture before setting.

5. Diurnal bands of platinum were produced in ordinary light when oxalic acid or one of its soluble salts diffused into a silicic acid gel containing: 10 cc. of 3N acetic acid, 10 cc. of water glass (d. = 1.16) and 0.8 cc. of 1% platinum chloride. Continuous light for three weeks caused reduction to black but gave no bands.

6. Pseudo, rhythmic, diurnal bands of platinum were made in a silicic acid gel containing: 10 cc. of 3N acetic acid, 10 cc. of water glass (d. = 1.16), 0.2 g. of oxalic acid, and 0.8 cc. of 1% platinum chloride, whenever exposure to light through a black grid with rhythmic openings was followed by several more days in the dark.

7. Diurnal bands result from the light reduction of alternate zones, followed by diffusion.

PHYSICAL CHEMISTRY FOR PREMEDICAL STUDENTS:

By E. C. H. Davies, is among the books recently published, by teachers at West Virginia University. The first edition, published in 1927, contained 27 illustrations, 57 tables, and 200 pages. The second edition is to be received before June 1. It will contain about 240 pages, over 60 tables, and over 30 illustrations. Edwards Brothers are the publishers.

DEPARTMENT OF DAIRY HUSBANDRY
A STUDY OF THE YELLOW COCCI WHICH SURVIVE
PASTEURIZATION

B. W. HAMMER and G. MALCOLM TROUT

(Jour. of Dy. Sci., Vol. XI, No. 1, Jan., 1928)

Investigations on the bacteria present in dairy products showed the frequent presence of yellow colonies on agar plates. These colonies seemed to be especially numerous on plates of pasteurized cream, or butter made from it. A study of 113 cultures isolated from butter, cream, milk, starter, and other sources about the dairy resulted in a division of the organisms into three types designated as Type A, Type B, and Type C respectively. A consideration of the various classifications studied suggest that Type A should be considered as *Sarcina lutea*. Type B as *Micrococcus varians*, and Type C as *micrococcus luteus*.

The organisms brought about various types of changes in milk, but these occurred comparatively slowly so that these organisms are probably of little importance from the standpoint of deterioration of milk or cream under practical conditions. In general these organisms resisted the usual pasteurization exposures for market milk; they were resistant in skim milk, whole milk, cream, and ice cream mix. The organisms were less resistant in milk containing sufficient acid to cause coagulation than in normal milk.

DEPARTMENT OF GEOLOGY

STRUCTURE AND SCENERY IN WEST VIRGINIA

JOHN L. TILTON

Bulletin of the Geological Society of America, March, 1927, page 217.

From Harpers Ferry, the gateway to West Virginia, one may travel westward by rail along the northern border of the state, or by auto he may follow the Valley of Virginia southward, and at Winchester turn westward toward Capon Bridge and Romney, or he may turn west just south of Harrisonburg and pass over the mountains to Franklin and to the mouth of Seneca Creek, or he may enter still further south past White Sulphur Springs to Lewisburg, and then go either west past Charleston or south past Princeton, and then go northwest to Huntington.

Whichever path is taken the roads lie first over mountain ranges where strata rise on edge high into the air, through divides in massive horizontal ledges that cap synclinal mountains, through watergaps where vistas of fertile valleys open like great pictures set in a mountainous frame, and through gorges where swift streams have cut their way across and through great arches of massive ledges. Then, ever westward, the folds become less steep, rising to the even skyline of the Appalachian Plateau, and dissected by valleys often canyon-like, and often wide in regions of weak strata. Along broad terraces are large cities, centers of trade in regions of coal, oil and gas, where mines dot the hillsides and oil derricks and gas wells mark the anticlines; then on out to the peaceful Ohio, rich in colonial history. Wherever one journeys from east to west there are to be seen the valleys and the beautiful mountains and hills of West Virginia—the geologist's paradise.

SCENIC GEOLOGY IN WEST VIRGINIA

(ILLUSTRATED BY LANTERN SLIDES)

JOHN L. TILTON

(Published in Vol. 2, Proceedings of the West Virginia Academy of Science, 1928, page 140.)

West Virginia contains portions of three physiographic provinces, across which the main roads already constructed make possible a circuit of the state, entering that circuit at any point. The plan here outlined crosses West Virginia from east to west in the northern part of the state, passes south in the western part of the state, then east along the Kanawha and New River, then north past Franklin to the starting point. Various scenic regions are designated and illustrated.

TWO ILLUSTRATIONS OF WIND ACTION IN WEST VIRGINIA

JOHN L. TILTON

(Published in Vol. 2, Proceedings of the West Virginia Academy of Science, 1928, page 145.)

Near Parkersburg, West Va., is a region of old sand dunes now grassed over—"Wheeling Fine Sand."

Near Uffington, West Va., at Raven Rocks, is a superb illustration of present wind action in the processes of weathering. In the midst of the bluff is a zone of white sand bearing evidence of wind action in crossbedding and curved bedding planes.

THE GEOLOGICAL REPORT ON HAMPSHIRE COUNTY, WEST VIRGINIA

JOHN L. TILTON and PAUL H. PRICE

Following a chapter on historical and industrial development is a chapter on geologic processes based on this particular region. Next comes a description of the various strata of the county, their structure, and their economic contents. This is followed by statistics of the region with reference to population, farm data, value of property, and climatological data. W. Va. Geological Survey, 164 pp. 1927.

THE GEOLOGICAL REPORT ON PENDLETON COUNTY, WEST VIRGINIA

Professor Tilton is the author of all that relates to the strata above the top of the White Medina sandstone. This includes the stratigraphy, the palaeontology, the geologic structure, the description of the cross sections, and the economic geology. There is a special chapter on what may be seen on trips out from Franklin, and another describing an igneous rock that is found in the southeastern part of the county. Under economic geology there is a description of deposits of iron ore, manganese, limestone, shale, sandstone, gravel, traces of coal, water for domestic purposes, and a description of the soils. W. Va. Geological Survey, pages 104-316. 1927.

DEPARTMENT OF HORTICULTURE

KNOWLTON, H. E.

1928. **Methods of Experimentation in Apple Sterility Studies.**
Proc. Am. Soc. Hort. Sci. 1927:91-93.

A critical review of methods that have been used in pollination experiments by investigators in the past.

-
1928. **Studies in Apple Sterility.** Proc. Am. Soc. Hort. Sci. 1927:111-114.

Three years results of tests of sterility of several commercial varieties of apples are given. They show that Stayman and Black Twig are self-sterile and Golden Delicious partly so. Delicious, Grimes, Jonathan and Ben Davis are excellent pollenizers for Stayman. Grimes and Black Twig are inter-sterile. Delicious and Grimes are good pollenizers for Golden Delicious.

-
1928. **A Study of the Hardiness of the Fruit Buds of the Peach.**
W. Va. Agr. Expt. Sta. Bull. 211. (In press).

This is an investigation of fruit bud hardiness of several varieties of peach in a number of sections of the state as influenced by temperature and by bud development during the winter. Pollen development was used as an index of bud growth. It was found that varieties differ greatly in hardiness, Greensboro and Carman being among the hardiest while J. H. Hale and Elberta were among the tenderest. The rest period ends earlier in Elberta than in Belle of Georgia or Rochester. This condition favors a greater growth response in Elberta during the warmer periods in January and February and more bud killing. Considerable differences in bud development of fruit buds on different parts of the tree by mid-winter were noticeable. Buds on the bases of terminal twigs were latest, buds on the middle of the twigs next and terminal buds farthest advanced. Fruit buds on short spurs were slightly ahead of basal buds on the outside terminals. Buds farthest advanced were the least hardy. Ovule development was noticeable at a later date than that of pollen. The first stages of ovule formation was indicated by growing points on the carpel wall on

January 3. Differentiation of integuments was found on March 3. Megaspore mother cells were not found on April 4 as flowers were opening.

KNOWLTON, H. E.

1928. **Varieties of Fruits for West Virginia. I. The Tree Fruits.** W. Va. Agr. Expt. Sta. Bull. 222. (In press).

Results of variety tests of the tree fruits at the West Virginia Agricultural Experiment Station together with a description of recommended varieties.

DEPARTMENT OF MECHANICS

G. P. BOOMSLITER

"Acceleration Stresses in Mining Hoisting Ropes." Proc. Am. Soc. Mining and Metallurgical Engineers, 1927.

Mathematical discussion, verified by test, showing that because of the elasticity of the rope the stress in the rope varies periodically under constant acceleration at the hoist and that the greatest stress is much greater than is usually considered, thus dangerously reducing the factor of safety used in design. Included in the paper is the description of a field test on a hoisting rope, including the test records and their interpretation. New formulas for design are presented, with the suggestion that a small increase in rope size may greatly increase the life of the rope.

"Acceleration Stresses in Hoisting Ropes," Bulletin No. 2, West Virginia University, Engineering Experiment Station.

An amplification of the above paper giving numerical examples of investigation and design of hoisting ropes by the suggested formulae. It contains a table giving hoisting data and calculated factors of safety for many coal mine hoists in the United States. The suggestion is made that hoisting ropes may fail because of repeated stress beyond the elastic limit of the rope.

DEPARTMENT OF PSYCHOLOGY

THE PSYCHOLOGY OF FRESHMAN RULES

JOHN E. WINTER

(School and Society, Vol. 25, No. 637, March 12, 1927)

This investigation was undertaken in an effort to determine the psychological causes of interclass conflicts which are a perennial problem in many of our universities. The study was confined to those universities and colleges having an enrollment of one thousand or more students.

The objectives outlined in the various sets of rules follow three general lines of thought. The rules are intended to (a) foster school spirit, (b) perpetuate revered traditions, or (c) discipline incoming freshmen.

The rules may be divided into three groups.

Group 1 contains what appear to be innocuous demands upon the freshman.

Group 2 contains strictures which can hardly be considered harmful, and which may prove to be commendable.

Group 3 contains strictures which are positively detrimental either (a) because they are discriminating in character, or (b) because they are objectionable in principle.

The devices commonly used for the enforcement of rules are open to serious criticism. The essence of the devices is alike for practically all,—an appeal to physical force, and an evident attempt at intimidation.

Conclusions. All attempts to coerce individuals or groups in an effort to develop college spirit are bound to meet with ultimate failure because they violate a fundamental law of mind. Coercion arouses resistance, not enthusiasm. It is as impossible to compel one to be enthusiastic as it is to compel him to hate or to love. Enthusiasm is spontaneous. What is needed, therefore, to develop enthusiasm is the creation of an environment that will engender spontaneity.

DEPARTMENT OF MATHEMATICS

SOME NEW METHODS OF APPROACHING THE FOUR
COLOR PROBLEM

CLARENCE N. REYNOLDS, JR.

(Proceedings of the West Virginia Academy of Science, Vol. I., pp. 91-97 [1927])

The problem of proving it possible to color in only four colors the map of any set of countries or regions on the surface of a sphere or other simply connected closed surface was first proposed in 1878. Since then many men have worked upon the problem, but no one has as yet published a correct solution of it. In 1923 Dr. H. R. Brahana of the University of Illinois published an account of the methods which had been used in studying the problem up to that time.¹ Since then some progress has been made. The purpose of this paper is to outline the methods of investigation, as distinguished from methods of demonstration, which the author has urged in deriving certain theorems concerning the four color problem which are to be published elsewhere; and to supplement Brahana's paper with an account of the progress which has been made by others since 1923.

¹"The Mapcoloring Problem," American Mathematical Monthly, XXX (1923) p. 234.

ON THE PROBLEM OF COLORING MAPS IN FOUR COLORS, I.

C. N. REYNOLDS, JR.

(*Annals of Mathematics*, Vol. 28, pp. 1-15 [1927])

The problem of coloring in four colors the map of a simply connected closed surface has been reduced to the problem of coloring maps in which certain configurations, known as reducible configurations, are absent. In this paper we shall develop some methods of so analysing the known geometric reductions of our problem as to discover and to prove some of their more important implications.

We shall use the reductions due to Kempe, Birkhoff and Franklin together with Errera's reduction of pairs of adjacent pentagons surrounded by hexagons. The reductions of Kempe, Birkhoff and Franklin are sufficient hypotheses for our final theorem that any irreducible map has at least twenty-eight regions. The use of one of Errera's reductions simplifies the proof of that theorem by eliminating much of the case making which would otherwise be necessary.

ON THE PROBLEM OF COLORING MAPS IN FOUR COLORS

CLARENCE N. REYNOLDS, JR.

(*Comptes Rendus de l'Association Francaise pour l'Avancement des Sciences*, pp 88-91 (1926) [not published until March, 1927])

Here we shall announce a sequence of propositions concerning maps which are irreducible with respect to the reductions of Kempe, Birkhoff and Franklin and with respect to one Errera's reduction. The role played by certain configurations in our proofs suggests an accompanying map of thirty-six regions which is irreducible with respect to all known reductions.

ON THE PROBLEM OF COLORING MAPS IN FOUR COLORS, II

C. N. REYNOLDS, JR.

(*Annals of Mathematics*, Vol. 28, pp. 477-492 [1927])

In this paper we shall continue the investigation of the implications of the published reductions of the four color problem which we began in the earlier paper of the same title, published in this journal. The two papers may be considered as a treatment of the arithmetic geometry of the irreducible map in so far as the properties of such maps may be found by summing over such maps the numerical attributes of neighborhoods of regions.

More specially, we shall strengthen and arithmetize two qualitative propositions, proven by Wernicke and Franklin, which read as follows:

(a) Every irreducible map must contain either two adjacent pentagons, or a pentagon adjacent to a hexagon.

(b) Every irreducible map must contain either a pentagon adjacent to two other pentagons, a pentagon adjacent to a pentagon and to a hexagon, or a pentagon adjacent to two hexagons. We shall also establish arithmetically other existence theorems of the same generic type in order to suggest ways of avoiding the difficulty which seems inherent in the reduction of pentagons.

DEPARTMENT OF PHYSICS

R. C. COLWELL

- (1) "Climbing and Spinning Tops"—School Science and Mathematics. February, 1927.

It is well known that a spinning top precesses about its point of support. If then, the top is made to change its point of support, the direction of precession will be changed. In this way a top may be made to walk around two circularly arranged wires. Mr. Fullmer, the mechanician of the Physics Department of West Virginia University, devised a suitably shaped ladder up which the top will climb. A double top may also be made which under certain conditions will spin or not spin about a central axis. These several tops were described and illustrated in this article.

- (2) "Some New Lecture Demonstrations in Gyroscopic Motion."—Science, June, 1927.

In further experimentation with tops, it was found that a rotating top would move down two inclined parallel wires with a hand over hand motion like an acrobat on a pair of parallel bars. If feet are placed upon this top, it will walk down an inclined board with a curious waddling motion. A rod with two tops hinged at the ends is useful for determining the action of precession.

- (3) "Operational Methods in Mechanics and Electricity."—West Virginia Academy of Science, Vol. 1, No. 1. November, 1927.

In certain physical problems the symbols of differential calculus may be used as though they were algebraic numbers; this reduces the solution of a differential equation to a problem in algebra. Several interesting problems in mechanics and electricity were attacked and solved by this method.

- (4) "Fading Curves and Radio Reception," by R. C. Colwell, O. R. Ford, and E. F. George. West Virginia Academy of Science, Vol. 1, No. 1.

The signals from station KDKA were measured over a long period by means of a super-heterodyne receiver connected to a rectifier and galvanometer. The fluctuations in the receiving current were then measured. By day the signal is weak but steady; at night it is stronger but fluctuates violently. On the average the night signal is greater than the signal by day.

- (5) "A Theory of Wireless Propagation," R. C. Colwell. West Virginia Science Bulletin, Vol. III, No. 1.

This theory postulates that all the radio waves are attached to the ground near the antenna. As the wave is propagated over the earth some of the waves leave the earth's surface and go out into space. In this way a sky wave is formed in addition to the ground wave. An attempt is made in this hypothesis to explain fading, night and day variations and so forth.

- (6) "A Multiple Electrical Connector." Patent Number 1659312.

This invention relates to multiple connectors designed for connecting a plurality of electric wires to a battery terminal or the like. An important object of the invention is to provide a device of this character which will be adjustable and wherein one or more wires may be connected to the device at the will of the operator. A further object of the invention is the provision of a connector which will grip the wires so as to prevent any displacement.

- (7) "Friction and Frictional Torque in Gyroscopic Motion." R. C. Colwell, Abstract in Bulletin of the American Physical Society, February, 1928.

In this article, the equations of motion of the walking tops are developed and it is shown mathematically why they

precess as they do. A new form of top is also described which consists of two spinning tops mounted upon an arm which is also free to rotate. Friction in the bearings will cause the whole arrangement to rotate. The precession of this top may be made to act with or against the frictional rotation so that this top will automatically reverse its direction of spin.

- (8) "The Rattling in Steam Pipes," R. C. Colwell. Science, April 13, 1928.

When the water in a cryophrus is at a temperature somewhat above freezing, it is possible to trap bubbles of water vapor in the liquid column by holding the cryophorus horizontally. Under the proper conditions of pressure due to motion of the liquid column, the bubble of water vapor will suddenly condense causing the water surfaces of the bubble to come together with a sharp click. These sharp clicks in the radiator of a steam heating system may be differentiated from the duller thud of the water hammer.

ARTICLES ACCEPTED FOR PUBLICATION

- (9) "The Walking Top." New York Tribune, N. Y. C.

A popular article describing the top which was shown to the members of the American Physical Society in February.

- (10) "Lecture Demonstrations in Physics." Accepted by School Science and Mathematics, by R. C. Colwell and M. C. Holmes.

Several new lecture experiments have been devised with the aid of Lee Fullmer, our mechanic. The four described in this article are: the electrified balloon, the climbing spark, the sliding electrodes, and the motor run by a concealed transformer.

- (11) "Modern Physics and Its Applications." R. C. Colwell, West Virginia Science Bulletin.

A popular article on X-rays, radium rays, and wireless waves.

DEPARTMENT OF PHYSIOLOGY

THE EFFECT OF ANOXEMIA ON THE SIZE OF THE
HEART AS STUDIED BY THE X-RAY

E. J. VAN LIERE

American Journal of Physiology. Vol. LXXXII. No. 3. Nov., 1927

The normal cardiac area was ascertained by taking x-ray pictures and measuring the cardiac silhouette with a planimeter. The animals were then placed in a steel respiratory chamber and subjected to a low atmospheric pressure corresponding to 2.5 to 8.3 per cent oxygen. About eight minutes were allowed to bring the animals to the desired level and the barometric pressure was held at this point for two minutes. The animals were then removed and an x-ray picture was taken at once and the cardiac area again determined. This was done on normal dogs, a rabbit and a guinea pig and on barbitalized dogs and cats.

In order to check the results an apparatus was arranged so that anoxemia could be produced while the animal lay directly underneath the x-ray tube.

The above animals all showed acute cardiac dilatation as evidenced by the x-ray, the increase in cardiac area varying from 7.7 to 18.85 per cent, depending upon the degree of anoxemia. The greater the degree of anoxemia the greater the cardiac dilation, up to a definite maximum. There was a rather marked individual variation in the response of the heart to anoxemia, some animals showing a cardiac dilation at a less reduction in oxygen percentage than others.

THE SIGNIFICANCE OF THE PERICARDIUM IN ACUTE CARDIAC DILATION PRODUCED BY ANOXEMIA

E. J. VAN LIERE AND R. S. ALLEN

The American Journal of Physiology. Vol. LXXXIII, No. 1, Dec., 1927

In a group of barbitalized cats, dogs, and monkeys the normal cardiac area was ascertained by taking x-ray pictures of the heart and measuring the cardiac silhouette with a planimeter. The animals were then subjected to anoxemia, corresponding to 2.5 to 5 per cent oxygen, by placing them in a suitable steel chamber from which air could be withdrawn. About eight minutes were allowed to bring the animals to the desired level and the barometric pressure was held at this point for two minutes. They were then quickly removed and an x-ray picture was taken at once and the cardiac area measured.

In order to check the results an apparatus was arranged so that anoxemia could be produced while the animal lay directly underneath the x-ray tube.

The pericardium was now removed; the animal was allowed to resume its normal breathing. Two hours after the operation another control picture was taken and the area computed. The animals were again subjected to the same degree of anoxemia as explained above. X-ray pictures were again taken and the area ascertained.

Animals with the pericardium removed tend to show a greater cardiac dilatation in severe degrees of anoxemia, particularly is this true in monkeys. The protective action of the pericardium as regards the prevention of acute cardiac dilatation probably never comes into play in the normal animal, except possibly in instances of extreme stress on the heart.

VASOMOTOR REFLEXES FROM THE ABDOMINAL VISCERA

J. F. PEARCY AND E. J. VAN LIERE

The American Journal of Physiology. Vol. 83, No. 2, January, 1928

In barbitalized dogs adequate stimulation of the abdominal viscera reflexly influences both the reflex and the tonus activity of the vasomotor center.

Various stimuli applied to different organs produce in some dogs depressor responses and in other dogs pressor responses. The factors which determine whether the response shall be pressor or depressor have not been determined. The splanchnic area always responded by vasoconstriction and the limbs by vasodilatation. The blood pressure may be determined by the resultant of the two, the heart rate remaining constant.

By chilling the animal, a pressor reflex could be converted into a depressor one. This phenomenon was reversible if the chilling was not too prolonged, otherwise it was persistent. The pressor-depressor reversal is not due to cooling the afferent arc of the reflex, nor is it related to shock.

The tonus of the vasomotor center in barbitalized dogs maintains a very uniform blood pressure level. Visceral stimulation frequently produced large Traube-Hering waves which persisted a quarter of an hour to two hours.

A SIMPLE ARTIFICIAL RESPIRATION MACHINE**E. J. VAN LIERE AND R. S. ALLEN**

**The Journal of Laboratory and Clinical Medicine. Vol. XIII, No. 7,
April, 1928**

An apparatus for the administration of artificial respiration for mammals was made from an automatic wind shield wiper. The latter is made by Folberth, Cleveland, Ohio. It was so modified that by the proper adjustments of two valves that the rate of respiration can be controlled; the volume of air at each inspiration may be controlled, and the ratio of inspiration to expiration may be controlled. It was found that this instrument is admirably adapted for small animals, but it may be used for large dogs weighing from 20 to 25 kilos. This simple air interrupter, moreover, may be used for purposes other than the administration of artificial respiration. It is not complicated, so that it does not get out of order easily and lastly, it is quite inexpensive.

DEPARTMENT OF ZOOLOGY

DUPLICITY IN BIRDS

F. E. CHIDESTER

Am. Nat., Vol. 61, pp. 272-279.

(1) Of seven specimens of posterior duplicity in the bird, two were cases of four wings and four legs, the remainder had duplicity of the legs only.

(2) Considerable variation occurred in the attachment of the legs, and in all cases the spinal columns were double posterior to the cervical region.

(3) Internally, the digestive tracts were double behind the gizzard, with either three or four cecae present.

(4) The kidneys were duplicated in specimens with four wings and four legs, but in one of the cases of two wings and four legs the anlage of the kidneys had divided and there were but two kidneys, widely separated.

(5) All the cases evidently resulted from posterior fission, as it would be most difficult to conceive of perfect fusion of the heads from independent primitive streaks.

DIVISION OF ZOOLOGY, W. VA. EXPERIMENT STATION

Problems attacked during the year 1927-1928, as reported by Dr. F. E. Chidester (through the Director of the Exp. Station) to the Inspector of Purnell Grants, and summarized for the A. A. A. S. meetings at Nashville, Tennessee, held December 27, 28, 29, 1927.

General statement of problems.

In general it is desired to find the most significant of the minerals contained in foods rich in the so-called "vitamins" and to experiment with those substances that apparently activate the internal secretions.

There must be quite definite correlation between the endocrine glands and the food stuffs, as affecting growth.

The thesis of the West Virginia workers is that an adequate diet must contain proteids, carbohydrates and fats with sufficient calories, but that extremely important supplemental influences are those due to the action of minute quantities of potent chemicals whose physico-chemical behavior activates and in many cases supplements the endocrine system as well as all other systems of the body.

F. E. CHIDESTER,¹ A. G. EATON, AND G. P. THOMPSON

The influence of adrenal cortex and medulla on the growth and maturity of agouti rats.

1. Growth of young rats is retarded by 0.5 gr. of either desiccated suprarenal medulla or cortex and is retarded, especially at first, by desiccated suprarenal cortex.

2. Young female rats fed 0.5 gr. of desiccated suprarenal cortex, (as shown by earlier litters), reach sexual maturity sooner than controls or those fed on 0.5 gr. desiccated suprarenal medulla daily.

No males were tested independently with females known to be mature, and we cannot, therefore, draw any conclusions regarding their age at sexual maturity.

(Approved for publication by N. J. Giddings, acting Director of the West Virginia Experiment Station as Scientific Paper No. 42.)

A. G. EATON, W. M., INSKO, G. P. THOMPSON, AND F. E.
CHIDESTER

The influence of adrenal cortex and medulla on the growth and maturity of young (white leghorn) chicks.

1. Chicks fed desiccated suprarenal medulla grew almost the same as the controls for the first three weeks. After

¹Subsidized by the Purnell Fund, the Merrill-Soule Co., and the G. W. Carnick Co.)
Anat. Rec. Vol. 37, No. 3., p. 326., 1928.

that time their growth was less rapid than the controls.

2. Chicks fed desiccated suprarenal cortex grew much more slowly at first than the controls. But by the end of the first eight weeks they began to grow more rapidly, and towards the end of the experiment, almost equalled the controls in weight.

3. If the weights of the testes are any indication of maturity, males receiving desiccated suprarenal cortex were more mature than either of the other lots, and those receiving desiccated medulla were less mature than those of the other lots. The average weight of the testes of the lot receiving desiccated suprarenal cortex was 0.2171 grams; the average of those receiving medulla was 0.1242 grams, while that of the controls was 0.2000 grams.

(Approved for publication by N. J. Giddings, acting Director of the West Virginia Experiment Station as Scientific Paper No. 41.)

G. P. THOMPSON, F. E. CHIDESTER,¹ AND A. G. EATON

The influence of whole pituitary and posterior pituitary on the development and maturity of pink-eyed yellow rats.

1. Young pink-eyed, yellow rats of pure stock receiving dosages of 0.15 grams and 0.30 grams of desiccated whole pituitary by mouth, grew at about the same rate as the controls for the first five weeks, but gained much more rapidly than the controls for the remainder of the experimental period. The two different dosages gave practically the same results.

2. Increased growth in rats fed on desiccated whole pituitary is much more marked in male than in female rats.

3. Contrary to some beliefs, no cases of viciousness or gigantism developed.

4. An apparently adequate basic diet consisting of KLIM and whole wheat may have accounted for the superior

¹Subsidized by the Purnell Fund, the Merrill-Soule Co., and the G. W. Carnick Co.
Anat. Rec., Vol. 37, No. 3, p. 326. 1928.

"self-control" evinced by these animals. Other investigators have noted extreme nervousness in rats on pituitary experiments.

5. Desiccated posterior pituitary fed by mouth in dosages of 0.15 grams and 0.30 grams had very little influence on growth.

(Approved for publication by N. J. Giddings, acting Director of the West Virginia Experiment Station as Scientific Paper No. 40.)

¹Subsidized by the Purnell Fund, the Merrill-Soule Co., the G. W. Carnick Co. and the Eli Lilly Co.)
Anat. Rec., Vol. 37, No. 3, pp. 325-326. 1928.

DEPARTMENT OF ZOOLOGY

THE OCCLUSION OF THE OESOPHAGUS AND
TRACHEA IN CROCODILIA AND SNAKES

A. M. REESE

Amer. Jour. Anat., Vol. 37, No. 2, May, 1926. pp. 195-212.

The temporary closure of a part of the anterior region of the digestive tract is commonly observed in the various classes of vertebrates in early embryonic life.

The closure usually takes place at about the time of the closure of the gill clefts in those forms in which the latter structures are transitory.

The closure may include not only a considerable portion of the oesophagus, but also the extreme anterior end of the trachea.

In the alligator the oesophagus regains its lumen, but remains separated by a thin partition from the pharynx until almost the time of hatching. The trachea reopens into the pharynx at an earlier date.

In the snakes (moccasin and copperhead), as in the alligator, the trachea first regains its connection with the pharynx, while cavities of the pharynx and oesophagus are long and separated by a thick, folded "occlusion membrane."

SOME REACTIONS OF SNAKES TO LIGHT AND TOUCH.
REACTIONS TO WHITE LIGHT

A. M. REESE

Jour. Comp. Psychology, Vol. 7, No. 3, June, 1927. pp. 237-245

1. The snakes studied showed a fairly distinct but not marked negative phototropism.
2. The experiments in phototaxis, or the reaction to the direction of white light, were not very conclusive. The land snakes gave indications of a slight positive phototaxis, while the experiments with the group of water snakes were not conclusive.
3. Snakes exhibit a distinct positive thigmotropism, which is more marked towards a rough than towards a smooth surface.
4. The reactions to light are doubtless influenced by the contact reactions.

DEPARTMENT OF ZOOLOGY

LELAND H. TAYLOR

1. A list of Chrysididae of Mount Desert, Maine. Biological Survey of the Mount Desert Region. Part 1, The Insect Fauna, p. 154, 1927.

A list containing 7 genera and 10 species, with collecting data, prepared from a determination of specimens submitted from this limited area of 100 square miles.

2. Die Goldwespen Europas von Dr. W. Trautmann. Entomological News, Vol. XXXVIII, pp. 253-254, Oct., 1927.

A review of an important recent work on European Chrysididae, or cuckoo wasps.

3. A list of Chrysididae of New York State. Cornell Univ. Agr. Exp. Sta., Memoir 101, pp. 990-991, Jan., 1928.

A list containing 9 genera and 23 species with collecting data prepared from a determination of specimens collected in New York State, for the comprehensive "List of the Insects of New York" at the request of the editor.

BULLETIN OF THE WEST VIRGINIA UNIVERSITY SCIENTIFIC ASSOCIATION

Vol. 2, No. 4. 1930



CONTENTS

Members of Board of Control and Board of Governors.....	2
Officers of the West Virginia University Scientific Association.....	3
Nota Bene (Editorial).....	4
Sessions of the Association.....	5
The Measurement of High Temperatures, A. G. Worthing.....	7
An Improved Method of Determining Carbon Dioxide, C. A. Jacobson and John W. Haught.....	8
A Survey of the Pottery and China Industry of West Virginia, W. A. Koehler.....	14
Variations in Radio Reception at Morgantown, R. C. Colwell and E. B. Whitman.....	23
A Modification of Ritter's Formula for Columns, L. D. Hayes.....	27
River Clays and the Pleistocene Problems in West Virginia, John L. Tilton.....	38
Developments in the Treatment of Acid Mine Drainage, Lewis V. Carpenter and A. H. Davidson.....	50
Agglutinins for Brucella Abortus in Human Serums in W. Va., R. S. Spray and B. W. Hess.....	58
Chemical Industry Dependent Upon Research in Pure Science, C. A. Jacobson.....	59
Mental Hygiene and Youth, R. M. Chapman.....	69
ABSTRACT SECTION.....	83
NEW BOOKS SECTION.....	103

WEST VIRGINIA UNIVERSITY

MORGANTOWN

Established February 7, 1867

THE STATE BOARD OF CONTROL

	Term Expires
H. N. BRADLEY, President, Charles Town	June 30, 1935
F. W. McCULLOUGH Treasurer, Charleston	June 30, 1931
JAMES S. LAKIN, Charleston	June 30, 1933
HERMAN G. JOHNSON, Secretary, Charleston.	

The State Board of Control has the direction of the financial and business affairs of the state educational institutions.

THE BOARD OF GOVERNORS

	Term Expires
EDWARD GRANDISON SMITH, President, Clarksburg, . . .	June 1, 1934
DAVID ALLAN BURT, Vice-President, Wheeling	June 1, 1934
FRANK HENNER BABB, Keyser	June 1, 1932
HUGH IKE SHOTT, JR., Bluefield	June 1, 1933
GERTRUDE ROBERTS, Huntington	June 1, 1933
ARTHUR BURKE KOONTZ, Charleston	June 1, 1932
CLEVELAND McSHERRY SEIBERT, Martinsburg	June 1, 1933
CHARLES THOMPSON NEFF, JR., Secretary, Morgantown.	

The Board of Governors has charge of the educational and administrative affairs of the University.

**OFFICERS
OF THE
WEST VIRGINIA UNIVERSITY SCIENTIFIC
ASSOCIATION**

1928 - 1929

President.....	F. A. Molby
Vice President.....	W. W. Hodge
Secretary	E. P. Deatrick
Treasurer	R. C. Colwell

1929 - 1930

President	W. W. Hodge
Vice President.....	F. E. Clark
Secretary	R. C. Colwell
Treasurer	P. D. Strausbaugh

PROGRAM COMMITTEE

1929 - 1930

R. C. Colwell
C. E. Lawall
R. S. Spray
H. E. Knowlton

PUBLICATION COMMITTEE

1929 - 1930

C. A. Jacobson,.....	Chairman
R. P. Davis	G. S. Dodds
A. M. Reese	C. R. Orton
J. E. Winter	

NOTA BENE

The West Virginia University Scientific Association is an organization of the scientific members of the faculty with a three fold purpose, namely:

First, to stimulate interest among its members, in scientific progress outside of the sphere of their own activities.

Second, to offer an opportunity for personal acquaintance with outstanding men in the different fields of science by inviting them to deliver lectures before the Association.

Third, to acquaint the people outside of the University, with the scientific progress that is being made at the University. This is accomplished through its published Bulletin.

The Association has been in existence since 1914 when Professor A. R. Whitehill was chosen as its first president. The first Bulletin of the Association was published in May 1922.

The Bulletin offers an opportunity for the Scientific members of the faculty not only to publish the results of original investigations of general interest, such as would be accepted in the national scientific journals, but also articles of interest especially to West Virginia and to the local community. Furthermore, the research workers at the University have an opportunity through the Bulletin, to acquaint the people both in and outside the University with the progress that has been made in any department. This is accomplished by the Abstract division of the Bulletin, which lists by departments, the titles of articles published in the scientific journals, and gives a brief summary of the results obtained.

A separate section for New Books published, has been included for the first time in this number.

At the Keyser meeting of the West Virginia Academy of Science, April 25-26, 1930, a motion was passed to invite all scientific societies of this state to become affiliated with the Academy, and also offering them space in the Academy Bulletin for all scientific papers that are passed by the Publication Committee of the Academy, to which each scientific society of recognized standing shall be entitled to one representative.

At the May 1930 meeting of the West Virginia Scientific Association a motion prevailed to accept the invitation of the West Virginia Academy of Science to affiliate, but the Society decided to proceed with the publication of the present Bulletin as planned.

PUBLICATION COMMITTEE.

SESSIONS OF
WEST VIRGINIA UNIVERSITY
SCIENTIFIC ASSOCIATION

1928 - 1930

At these sessions the following addresses were delivered:

- October 25, 1928. **"My Recent Trip to Europe,"** by Dr. John A. Eiesland, head of the Department of Mathematics, West Virginia University. A general discussion of the work done in mathematics at a few of the larger Universities in Europe.
- November 27, 1928. **"Coal,"** by Dr. S. W. Parr, President of the American Chemical Society. The lecturer discussed briquetting and coking of coal and its manifold applications to industry.
- December 18, 1928. **"The Scientific Work of T. C. Chamberlain."** Various phases of his work were discussed by the following professors: P. D. Strausbaugh, H. E. Cunningham, W. J. Yeaton, H. M. Fridley, S. L. Galpin and John L. Tilton.
- January 25, 1929. **"An Account of Human Embryology,"** by Dr. G. S. Dodds, Professor of Histology and Embryology, West Virginia University. A discourse on the development of the human embryo, illustrated by lantern slides and several specimens.
- April 6, 1929. **"Some Problems in Botany,"** by Dr. A. S. Hitchcock, U. S. Department of Agriculture, Washington, D. C. The lecture was illustrated by lantern slides.
- April 16, 1929. **"Clinical Psychology,"** by Dr. J. E. W. Wallin, Clinical Psychologist for the State of Ohio. A discourse relating mental health of both children and adults to clinical psychology.
- April 24, 1929. **"Organic Compounds Related to Chaulmoogra Oil,"** by Roger Adams, head of the Department of Chemistry, University of Illinois. The preparation of synthetic organic compounds similar to those obtained from chaulmoogra oil, was explained.
- October 25, 1929. **"The Development of the Incandescent Light,"** by J. M. Ketch, Illuminating Engineer of the Nela Research Laboratories of the General Electric Company, Cleveland, Ohio. The lecturer traced the progress in lighting from the tallow dip to the present inert gas incandescent bulb, showing numerous specimens of ancient lamps.
- November 22, 1929. **"The Ceramic Industry in West Virginia,"** by Dr. Walter A. Koehler, Assistant Professor of Chemical Engineering, West Virginia University. An illustrated lecture on the White

Ware industry of this state, emphasizing its tremendous magnitude and importance.

December 13, 1929. **"Mental Hygiene and Youth,"** by Dr. R. M. Chapman, Professor of Psychiatry, University of Maryland Medical School, and Medical Superintendent of the Sheppard and Enoch Pratt Hospital, Towson, Maryland. A lecture tending to show the importance of proper direction for the psychic life of the young in order to avert the pitfalls so common in later life.

January 24, 1930. **"The World Beyond,"** by Dr. R. S. Spray, Professor of Bacteriology and Hygiene, West Virginia University. A lecture on types and characteristics of bacteria, showing numerous specimens of some of the most virulent types.

February 28, 1930. **"The Measurement of High Temperatures,"** by Professor A. G. Worthing, head of the Department of Physics, University of Pittsburgh. A lecture dealing with various sorts of pyrometric measurements and all referred to some unit as for example the melting point of gold, 1336°, on the Absolute Scale.

March 28, 1930. **"The Utilization of Land in the Mountain Sections of West Virginia,"** by Dr. A. J. Dadisman, Professor of Farm Economics and Farm Economist, West Virginia Agricultural Experiment Station. A lecture dealing with the economic problems of the farmer and the best use to which the arable land of the state can be put.

May 2, 1930. **"Some Striking Natural Features of the West,"** by Dr. R. C. Spangler, Professor of Botany, West Virginia University. A lecture, illustrated by lantern slides, giving some of the things a tourist sees when traveling through Yellowstone, Yosemite, the Environs of Puget Sound, and the Big Trees country of California.

THE MEASUREMENT OF HIGH TEMPERATURES

By A. G. WORTHING,
Head of Department of Physics
University of Pittsburgh.

For the discussion of the evening, high-temperatures were defined as temperatures of the order of that of melting gold and higher. First there was given a description of the work of Day and Sossman with gas thermometers by which the temperature of melting gold—1336°K., the starting point of optical temperature measurements—was determined. Then the black body—a uniformly heated cavity with a small opening in its wall serves as the most convenient form—its laws, and in particular, its brightness variation with temperature were briefly discussed. Next it was shown how a black body could be brought to and maintained at the temperature of melting gold; how, when at that temperature and with the aid of rapidly rotating sector discs, an optical pyrometer could be sighted on it and calibrated over a wide range of temperatures up to and including the gold point; and how, with the same apparatus but with varied temperatures of operation for the black body, those temperatures could be measured and the calibration of the optical pyrometer could be extended upward over any desired range. Such a calibration in imitation was carried out during the talk. Finally it was shown how ordinary materials having high melting points could be shaped to form the walls of black body enclosures, so that when operated at high temperatures their apparent surface temperatures—strictly speaking brightness temperatures—may be related to their true temperatures; and how relations so attained are afterwards used in measuring characteristic true temperatures. As true temperatures thus determined, 2450°K. as the operating temperature of the ordinary vacuum lamp, 3655°K. as the melting point of tungsten and others were cited.

AN IMPROVED METHOD FOR DETERMINING CARBON DIOXIDE

By C. A. JACOBSON and JOHN W. HAUGHT.

More or less difficulty has been experienced in getting satisfactory checks on successive determinations of carbon dioxide even when the most reliable methods were employed. Students taking our course in Advanced Quantitative Analysis always had difficulty in getting two successive analyses to check within 0.5 %, or to obtain results that came within that percentage of the true value.

Consequently we undertook a series of determinations of carbon dioxide in limestone by the following methods, with a view to testing their relative efficiency: The Fresenius-Clas-sen Method, The Mohr Alkalimeter, The Knorr Method, and The R. C. Wiley Method (Jour. Am. Chem. Soc. Vol. 51, p. 222).

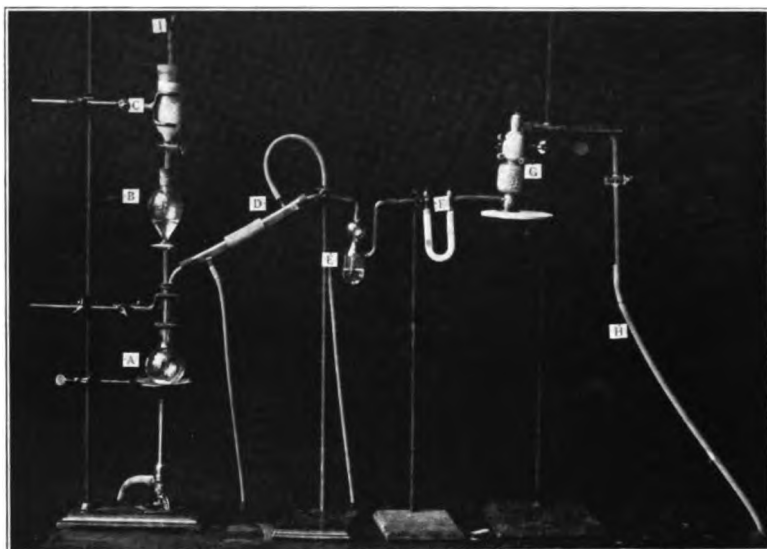
The following table gives the results obtained on an analyzed sample of limestone:

TABLE I.

No.	Method Used	Acid	Wt. Sample	Wt. of CO ₂ obtained	% CO ₂	Accepted Value	Error
1	Fresenius-Claisen	H ₂ SO ₄	.5639	.2224	39.44	40.86	-0.42
2	"	"	.47508	.1854	39.03	40.86	-1.83
3	"	"	.52175	.2050	39.29	40.86	-1.57
4	"	HCl	.48261	.1968	40.78	40.86	-0.08
5	"	"	.5065	.2067	40.81	40.86	-0.05
6	"	"	.5937	.23856	40.18	40.86	-0.68
7	"	"	.51368	.2110	41.07	40.86	+0.21
8	"	"	.5079	.20868	41.08	40.86	+0.22
9	Mohr's Alkalimeter	"	1.04132	.4243	40.74	40.86	-0.12
10	"	"	1.15606	.47231	40.85	40.86	-0.01
11	"	"	1.12474	.4388	39.01	40.86	-1.85
12	Wiley's Method	H ₂ CrO ₄	.1190	.04888	41.08	40.86	+0.22
13	"	"	.1605	.0663	41.30	40.86	+0.44
14	Knorr Apparatus	"	.1087	.04284	39.13	40.86	-1.73
15	"	"	.1212	.04747	39.18	40.86	-1.68
16	"	"	.1372	.05496	40.06	40.86	-0.80

From the results listed in Table 1, and many others, we learned that concordant analyses of limestones are not easily obtained with the ordinary methods. In view of this fact one of us set about designing an apparatus by which, it was hoped, better results would be obtained.

We therefore constructed the apparatus shown in the illustration.



The sample is weighed into the 100 cc. round bottom flask A, closed by a rubber stopper holding the separatory funnel B and the bent tube of the condenser D. The stem of the funnel B is drawn out to a fine capillary opening, ending about an inch from the bottom of the flask. The separatory funnel is in turn fitted with a glass stoppered absorption tube C containing ascarite provided to remove CO_2 from the aspirated air after the reaction is over. The condenser is made by cutting off the closed ends of two small side neck test tubes and fitting the cut ends together with a piece of rubber tubing. Tube E serves the two fold purpose of absorbing most of the moisture from the CO_2 as well as to permit the regulation of

the flow of gas through the apparatus. The U tube F is filled with dehydrite (tri hydrated magnesium per chlorate) for the purpose of taking out the last traces of water. The lower compartment of the Fleming absorption tube G is filled with ascarite (sodium oxide in asbestos) and the upper compartment with dehydrite which serves to retain any moisture that may be formed in the ascarite bulb during the CO_2 absorption. The upper end of the Fleming bulb is connected with the suction tube H, connected either with a filter pump or an aspirating bottle by means of a glass stopcock for the purpose of regulating suction.

PROCEDURE

Before the determination is started the apparatus is carefully tested for leaks by applying suction at H. A bubbler, not shown in the photograph, is inserted between G and H for this test, and then removed. Leaks are seldom encountered, however, if the glass stoppered joints have been previously tested. All rubber connections are made by heavy wall pure gum tubing. The rubber stoppers used are small which more readily permit of making tight joints.

Having proved the apparatus tight, about 3 to 4 cc. H_2O are added to the sample (about 0.7 gram) through B, after which about 5 cc. of 60% perchloric acid diluted to 15 cc. with water are measured into B, and then the absorption tube C fastened into place. The Fleming absorption bulb G is weighed, preferably before testing the apparatus for leaks. A slightly diminished pressure in the apparatus is made by turning the stopcock inserted between H and G, and then the acid in B started to drop into A, in very small droplets to begin with. As the CO_2 is generated the bubbles can be counted in E, and the speed of the reaction so controlled that only about one bubble per second passes through the tube with a 4 mm. bore. Two bubbles per second is too fast for perfect absorption. As the reaction in A slows down the acid is added faster until all has gone in. Then the stopcock in C is closed and the flask A gently heated, so as to maintain the same rate of flow

of gas through E, until the liquid in A boils. Boiling is not continued for more than a minute, after which the flame is turned down gradually. As soon as the tendency to suck back appears, the stopcock C is slowly opened to allow air to enter and replace the gradually condensing water vapor in A. The aspiration of purified air through the apparatus at the same rate is continued for about an hour after the liquid in A has attained room temperature. The increase in weight of G represents the weight of carbon dioxide liberated from the sample taken.

Some of the determinations made with this apparatus are given in the following table:

Comparing these results with those obtained by other methods it is apparent that a simple apparatus has been designed that yields close and more concordant results in the determination of carbon dioxide in a carbonate. The apparatus is simple and can be assembled from the stock usually found in any chemical laboratory. The average student in quantitative analysis is able to get satisfactory results on any carbonate by using this method, and we recommend it to all who are seeking a simple and reliable method for such determinations.

TABLE II.

No.	Type of material analyzed	Wt. of Sample	Acid used	Absorbent	Wt. CO ₂ obtained	Percentage CO ₂	Accepted value	% Error	Analyst
KOH in									
1.	No. 46 Analyzed limestone	.69206 g	HCl	Geisler	2828	40.86	40.86	0.00	J. W. H.
2.	"	.69626	HCl	"	.2844	40.84	40.86	-.02	"
3.	"	.60986	HCl	"	.2479	40.65	40.86	-.21	"
4.	"	.74196	H ₂ SO ₄	"	.28402	38.28	40.86	-2.58	"
5.	"	.72676	H ₂ SO ₄	"	.2762	38.00	40.86	-2.86	"
6.	"	.61086	HClO ₄	"	.2495	40.84	40.86	-.02	"
7.	"	.65406	HClO ₄	"	.2677	40.92	40.86	+.06	"
8.	"	.72956	HClO ₄	"	.2982	40.87	40.86	+.01	"
9.	"	.75276	HClO ₄	"	.30832	40.96	40.86	+.10	"
10.	"	.59236	HClO ₄	Ascarite	.2411	40.70	40.86	-.16	"
11.	"	.71026	HClO ₄	"	.28862	40.63	40.86	-.23	"
12.	Pure Iceland Spar	.8494	HCl	"	.3736	43.98	43.97	+.01	C. A. J.
13.	"	1.1499	HCl	"	.5062	44.02	43.97	+.05	"
14.	"	.6667	HClO ₄	"	.2919	43.78	43.97	-.19	"
15.	"	.8741	HClO ₄	"	.3840	43.93	43.97	-.04	"
16. No. 48 Analyzed limestone									
17.	"	1.0253	HCl	"	.3042	29.67	29.79	-.12	"
18.	"	1.0497	HCl	"	.3122	29.74	29.79	-.05	"
19.	"	.8578	HCl	"	.2539	29.68	29.79	-.11	"
20.	"	.4778	HClO ₄	"	.1440	30.13	29.79	+0.34	E. G. S.
21.	"	.4512	HClO ₄	"	.1350	29.92	29.79	+0.13	"
22.	"	.4197	HClO ₄	"	.1250	29.79	29.79	0.00	K. V. S.
23.	"	.5864	HClO ₄	"	.1739	30.10	29.79	+.31	"
24.	Dolomite	.7802	HClO ₄	"	.3693	47.33	47.24	+.09	W. S. L.
25.	"	.70435	HClO ₄	"	.3365	47.36	47.24	+.12	W. N. D.
26.	"	.72385	HClO ₄	"	.3407	47.06	47.24	-.18	W. N. D.
	"	1.2021	HClO ₄	"	.5700	47.41	47.24	+.17	W. N. D.

A SURVEY OF THE POTTERY AND CHINA INDUSTRY
OF WEST VIRGINIA

By W. A. KOEHLER,

Department of Chemical Engineering.

In defining the term "whiteware," it is not sufficient to say that it is a white appearing, ceramic product, in fact, all whiteware is not strictly white. Whiteware is a fired clay product, the whiteness of which is not due to a superficial white coating of enamel, but is inherent throughout the body. The Chinese were the first to manufacture whiteware, and their ware was also translucent to light. Their particular ware was called china ware which was later shortened to china. The Chinese kept their process very secret and the Europeans had to get along with a cheaper ware or buy from the Chinese. The cheaper ware was Delft, a crude earthenware made of a dark clay and covered with a white enamel, just as is the enameled iron ware we use to-day. This enamel was called a tin enamel, because the whiteness was caused by tin oxide, a snow-white compound, and this same tin oxide is used in our white enameled ware to-day. The first whiteware came to Europe from China a little before the time Columbus discovered America and its popularity spread very rapidly. Later, China also went under the name of "porcelain," the two words popularly speaking being synonymous.

Josiah Wedgwood, a contemporary of George Washington, developed to perfection a white earthenware. Its distinguishing characteristic from China being that the body is porous and transmits no light. The glaze is a crystal clear glass just as it is on our present whiteware. We therefore have two chief classes of whiteware: china or porcelain and earthenware. In the firing of china the heating is so severe that considerable melting takes place in the body so that on cooling it is glassy, or to use a ceramic term, it is vitreous. This glassiness makes the ware translucent to light, the translucency being the chief characteristic of china. Because of this glassiness, china has a fairly clear ring when struck with a piece of metal. Earthen-

ware is not heated as much as is china and only a small amount of glass is formed and therefore the ware is not translucent to light, unless, perhaps, it is examined in very thin sections. Earthenware is also porous, in some cases 16 percent of the volume being made up of pores. Earthenware has no clearing when struck sharply. The grade of earthenware has gradually been improved, the firing has been carried to a higher temperature, and the porosity has been reduced to eight percent by volume. American manufacturers like to refer to this ware as semiporcelain, or semivitreous ware.

A fairly wide variety of articles are manufactured in the class of whiteware, some being vitreous and therefore belonging in the china or porcelain class, and others being non-vitreous, and therefore belong in the earthenware class. Both kinds are covered with a clear glaze, to add to the luster and to make cleaning easier.

Dinner ware is manufactured in both classes: the fine china so well known in the American home, and the earthenware or crockery which is perhaps still better known. Floor tile should be hard in order to withstand wear and shock, and should have practically no pores to soak up moisture or to hold dirt. Both requirements are fulfilled by making the tile vitreous. Wall tile are earthenware and are coated with a glaze, just as tableware is. Sanitary ware is made in both classes, some potteries in West Virginia make vitreous sanitary ware, others earthen sanitary ware. Electrical porcelain is all porcelain, that is, it is vitreous. High tension electrical porcelain exemplifies the highest degree of vitrification of any whiteware made.

To summarize, whiteware as made in this state comprises table ware, both china and earthenware, floor tile, wall tile, sanitary ware and electrical porcelain.

The basic ingredients of whiteware is china clay, a nearly snow-white clay; it is derived from kaolin. Kaolin as it occurs in nature contains free sand; this is removed by a washing process and the purified material is called china clay. China clay has the valuable property of remaining white after it is fired.

A great deal of china clay is imported into the United

States, about a third of a million tons being imported annually. China clays derived from American kaolins were once considered unsuited for whiteware manufacture. To-day, 13 of the 24 potteries in this state use American china clays, three using it exclusively, and 10 use it mixed with the English clay. The other 11 potteries use English china clay only. The amount of American clays used in whiteware is being increased from year to year, so that some day we may be independent of English clays. English and domestic china clays cost about \$30 and \$22 per ton respectively, delivered in West Virginia. Our domestic china clays come mainly from North Carolina, Georgia and Florida.

If we attempt to produce pottery from china clay alone, we run into three major difficulties: (1) The clay does not possess sufficient plasticity to make it work well, (2) It is extremely weak after drying and would probably break before it could be fired, (3) It requires too high a temperature to fire it. To overcome the first two difficulties a highly plastic clay called ball clay is mixed with the china clay. It in itself is too plastic, but mixed properly with china clay, the right degree of plasticity is obtained. The ball clay also adds to the strength of the unfired ware, or as the pottery men call it, the green ware. The shaped ware is subjected to a number of finishing processes before it is fired, and therefore is handled considerably so that mechanical strength is very desirable. Ball clay does not fire to as white a color as does china clay, that is, it imparts a slight yellow tinge to the finished ware, and for that reason the amount of ball clay is kept at a minimum consistent with good plasticity and good mechanical strength. Ball clays, like china clays, are imported from England but local clays from Kentucky and Tennessee are also used. English ball clays cost about the same as English china clays, but domestic ball clays cost about half as much. In order to reduce the firing temperature required, a fluxing material is added. This flux melts at a comparatively low temperature and dissolves a little clay, then on cooling, the glass formed by this melting binds the ware into a firm unit. The flux almost universally used in this

country is feldspar. Feldspar suitable for pottery use is found in North Carolina, Tennessee, Maine, South Dakota and Canada. Feldspar, ground, sells at about \$18 per ton delivered in West Virginia. English potters prefer to use Cornwall stone instead, and for some of their china they use bone ash, made by burning bones. Such china is then called bone china.

But if we attempted to fire such a body consisting of china clay, ball clay and feldspar, we would find that when the ware got very hot it would soften and lose its shape. Finely ground sand is therefore added to make the ware hold its shape, and for this reason is sometimes referred to as the skeleton of the ware. This sand also helps to reduce warping when the ware is drying. This finely ground sand, usually called potters' flint, is obtained from Illinois, Tennessee, Ohio, Pennsylvania and West Virginia, at about \$14 per ton delivered in this state. One-half of the potteries manufacturing whiteware in this state use our Berkeley Springs sand.

The main materials for a whiteware body then are the following:

China Clay	32 %
Ball Clay	17 %
Feldspar	15 %
Flint	36 %

The percentages given are for a particular china body and are only approximate.

If a pure white body is desired, something must be added to mask the slightly yellow color imparted by the ball clay. The common material used is one of several compounds of cobalt. Cobalt has the property of turning blue when heated with a silicate and this blue color whitens the ware in a similar way that blueing whitens laundry.

In recent years, however, ivory ware has become popular and has stimulated trade appreciably. In ivory ware, clays are especially selected to give a pleasing ivory tone, and the cobalt is, of course, omitted. Nearly all of the potteries in West Virginia making semi-vitreous dinner ware produce ivory as well

as pure whiteware. Ivory ware, however, is classed as whiteware.

All whiteware except floor tile and refractory porcelain is glazed. As before mentioned, the glaze adds luster to the ware and makes it more sanitary. The glaze is a clear glass, related to window glass, but with its composition so changed and adjusted that the thermal coefficients of expansion of the glaze and the body it covers are nearly alike. This problem has been fairly well solved, especially in those potteries having technical men on their staffs. If the two expansions are not the same, the glaze will crack (pottery men say it crazes) or it will scale off, depending on which has the greater coefficient of expansion. In addition, crazing may be caused by a gradual expansion of the body due to contact with moisture; crazing from this cause usually does not manifest itself until after several years.

In all whiteware except electrical porcelain made in this state, the unglazed body is first fired to its maturing or finishing temperature. It is then called biscuit ware. The glaze is then applied. The prepared glaze is finely ground, mixed with water to form a slip of about the consistency of cream, and the biscuit ware is dipped into this. On removal, the glaze is allowed to dry and the ware is again fired, this time to a lower temperature, just enough to melt the glaze. The surface tension of the molten glaze pulls the glaze evenly over the ware.

Whiteware is fired in the usual type of periodic kilns, sometimes called bottle kilns on account of their shape. There are 134 such kilns in this state firing bisque ware and 82 firing glost ware. In addition there are 29 car tunnel kilns firing bisque, glost, or decorations.

Some dinner ware is sold as plain whiteware, others as decorated ware. Some decorations are placed on the biscuit under the glaze, others are placed on the glaze, the two kinds being called **under glaze** and **over glaze** decorations respectively. Under glaze decorations are more permanent, for they are protected by the glaze, but as is apparent, in the manu-

facturing process the decorations must be fired to the temperature required by the glaze, which is above 1000°C . in white-ware manufacture. Few bright colors can stand such severe temperatures. When over-glaze decorations are applied, the glaze has already been fired, and in the special decorative fire which follows the temperature can be kept much lower, usually below 800°C . Hotel and restaurant ware is usually under glaze decorated on account of the hard ushage it receives, but the modern trend to colors is forcing the manufacturers to produce some over-glaze decorated ware also.

West Virginia has 24 potteries producing whiteware. They produce dinner ware, hotel ware, floor tile, wall tile, electrical porcelain, sanitary ware and art ware. With four exceptions all the potteries are located on the Ohio river. The tip of the northern pan-handle contains eight plants in Chester and Newell. These two cities along with East Liverpool just across the river in Ohio comprises the East Liverpool pottery district, the second largest such district in the country. The whiteware industry in West Virginia produces ware valued at approximately ten and one-half million dollars and gives employment to a little over 400 workers. It ranks eighth among the manufacturing industries of the state. The total whiteware manufactured in the United States is valued at \$111,000,000 so that West Virginia supplies about 10 percent of the pottery produced in this country. Our state ranks third in pottery manufacture, giving first and second place to Ohio and New Jersey respectively.

Although American potteries operate more efficiently than do European ones, and on account of use of modern machinery produce more ware per man, they are not without their troubles. For one thing, American pottery manufacturers find foreign competition very active, and this in face of the fact that the import duties range from 45 to 70 percent. An American made 10-cent cup bought at Woolworths, was made by a number of workers each averaging over \$8.00 a day, while a foreign made cup, also selling for 10 cents, was made by workers averaging \$1.00 a day. On account of the lower wages

paid in Germany, the manufacturers of electrical porcelain in that country can make the ware, ship it across the ocean, pay the import duty of 60 % and send it on to San Francisco and deliver it to the jobber there at a lower figure than the cost of production in West Virginia. A remedy suggested by some potters is that import duties be regulated according to relative wage scales of each country. Another remedy suggested is that the valuation on imported ware be based on the value of a comparable American product in this country instead of on the foreign value. The present House Tariff Bill passed last May carries such a provision, but the Senate hasn't acted on the bill yet. Cheap imported Japanese ware is especially bothersome to American potters. During the period that American pottery production has doubled, Japanese imports have increased 1,200 %. Fifty-three percent of all imports of decorated china are coming from that country. Of all the pottery and porcelain sold in this country, over two-thirds is imported.

Importers also use various schemes to avoid legitimate payment of duties. There are 47 ports of entry used by importers of table ware. Importers will have shipments divided to a number of ports to reduce the chance of being caught in the Anti-Dumping Law. One importer attempted to enter a large lot of tea pots covered with rattan at a duty of only 20 % on the basis that the rattan was the real article of merit and the enclosed tea pots were merely incidental. One importer succeeded in entering a shipment of hand painted pottery duty free as "works of art" coming under "original paintings in oil, mineral, water or other colors." Another importer had tea pots sent in one shipment and their covers in another, so as to bring each in as "incompleted ware" at a reduced rate, on the claim that it would require American labor to place the covers on the teapots.

American manufacturers, however, have no objection to the importation of European wares of good quality and decoration. These do not force the development of the American industry in the direction of an inferior product. Haviland,

Wedgwood, Minton, Copeland, Doulton and several others are looked upon by American potters as desirable importations.

Another difficulty the American potters have to face is the prestige enjoyed by European pottery in the eyes of the American public. To the American buyer, the American made automobile is a finer piece of art than the European made automobile, but not generally so in pottery.

At the beginning of the 80's of the past century one pottery just beyond the West Virginia border decided to change over to the manufacture of white table ware, but it found resistance to American-made ware almost insurmountable. In order to get started they decided to use as their stamp on the under side of the ware the well known English mark, the lion and the unicorn. With this mark their business began to prosper. They continued thus for 15 years, after which the officials felt that their wares could sail under American colors. They then not merely discontinued the English mark but designed one in defiance. The design was the American Eagle rampant and the British Lion prostrate. This mark was continued until 1904, when they adopted a more conventional type.

About the same time another pottery was feeling the same kind of resistance to its American made ware, and it changed its stamp to "Daulton." The American public apparently goes more by pronunciation than by spelling for their market expanded very markedly. The mark on the famous English ware of same pronunciation then as now was "Doulton."

If we could establish in this country a definite American design and decoration which would especially appeal to the public, a big gain would be made, but we are still far from that stage. The American jobber will go to Europe, buy samples of its best sellers for the year, and bring them to our manufacturers with the question, "How nearly can you copy this without getting into infringement difficulties and what is the lowest price at which you can do it?" The designer may then work several weeks on the design, and cost accountants may figure carefully down to the last cent, only to find that a competitor

has underbid them by a few cents on a dozen pieces. Under such conditions we are not rapidly developing an American art in our pottery.

VARIATION IN RADIO RECEPTION AT MORGANTOWN

By R. C. COLWELL and E. B. WHITMAN.

For the last three years, we have been making accurate measurements upon the energy received from the broadcasting station KDKA at Pittsburgh. The incoming signal is made to actuate a galvanometer needle and the readings of the galvanometer are recorded by a moving pencil. The curve traced out by this pencil is called a fading curve. We found that these curves may be divided broadly into two types, one a fairly steady curve, the other rather fluctuating. Figure (1) is a representation of an irregular curve. The two types (about ten of each) have been averaged over the energy received per minute before and after sunset. Figures (2) and (3) have been plotted from the results of the averaging. It is apparent that the curve for the fine days fluctuates more than that of cloudy days.

A year or so ago, someone advanced the theory that a

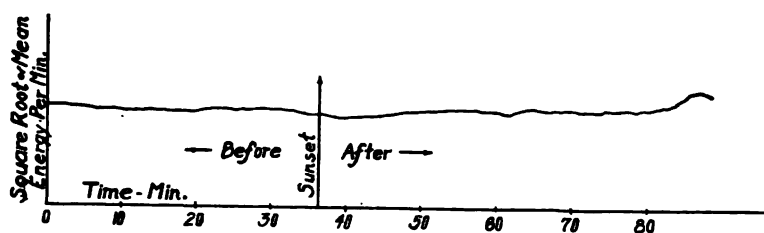


Fig. 1.

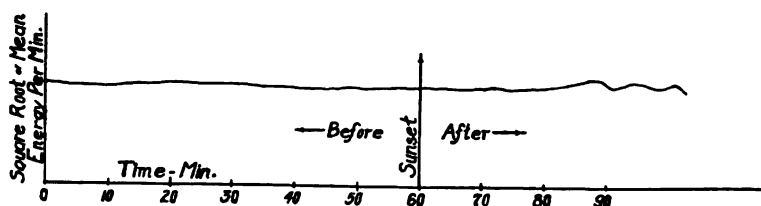


Fig. 2.

bright full moon should act upon the atmosphere much like sunlight and that the reception on moonlight nights should be below that of moonless nights and that the fading curve should look like a daylight curve. The first curve taken in full moon-

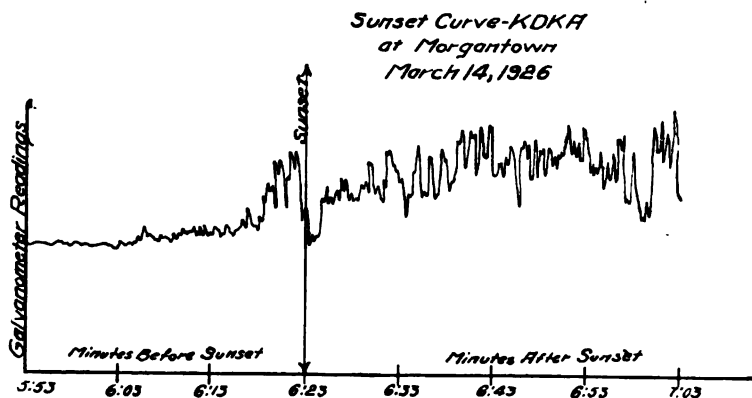


Fig. 3.

light seemed to confirm this hypothesis. It is shown in the lower part of Figure (4). The curve is almost a straight line without variations, a typical daylight curve. However, the other curves of Figure (4) were also taken on clear moonlight nights and these curves show the usual night reception. These two curves are interesting, because the upper one exhibits rapid fading, while the middle one shows periodic fading of about a five minute period. It is worth noting that the ear would not follow the rapid variations in the upper signal of January 6, 1928; but the slower fading of November 17, 1926, is clearly

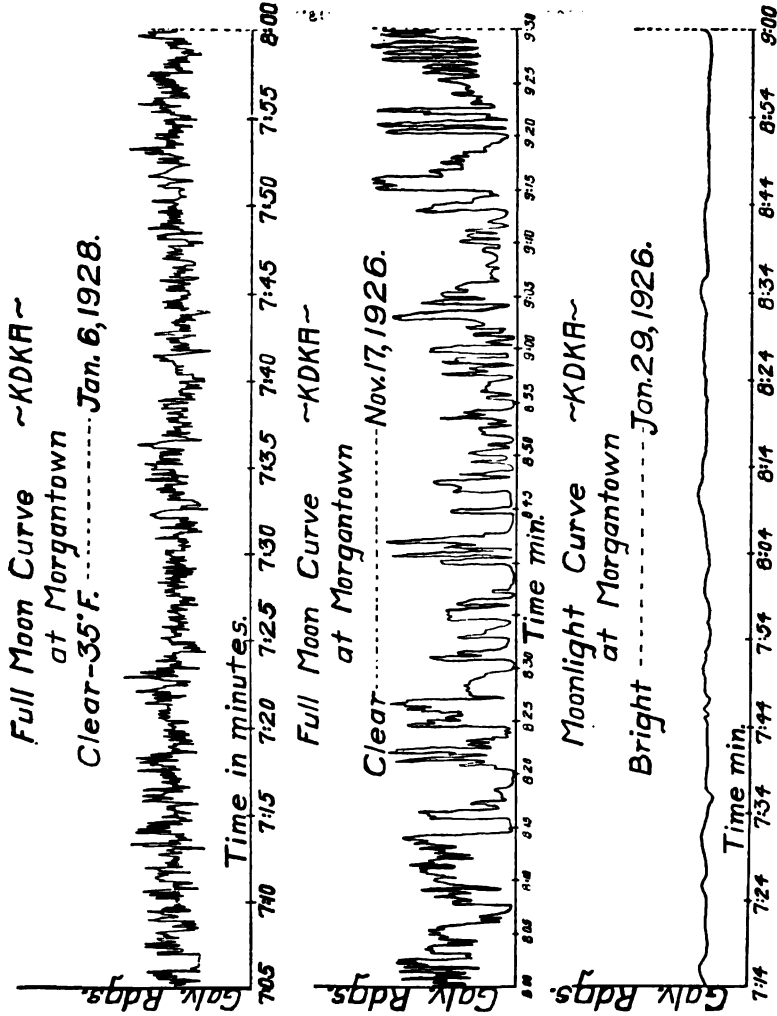


Fig. 4.

defined to the ear; in fact, the signal faded clear out about every five minutes. It is rather unusual to have a powerful signal only seventy miles away fade in this fashion.

A MODIFICATION OF RITTER'S FORMULA FOR COLUMNS

By LESLIE D. HAYES,

Professor of Machine Design and Construction,
West Virginia University.

In the preparation of this article there has been no attempt to make any exact mathematical analysis of the stresses which occur in columns. Numerous other writers have spent years of time and hundreds of pages of abstruse mathematical calculations in the derivation of complex formulas, only in turn to present a similar number of pages in demonstrating why these same formulas can never be applied to the computation of columns as they occur in engineering practice. It is recognized that, entirely aside from the accuracy of our knowledge of the conditions actually existing in a column, there remains in the design of columns the necessity of using some formula which, without unnecessary complications in its solution, shall give results on the side of safety and reasonably economical in material. It is in the hope of aiding in the selection of a practical formula of this nature that this study has been undertaken. If it can be shown that the results obtained are in reasonable agreement with the records of reliable commercial tests the effort made will have been justified. This present article deals with the nature of the formula and the degree to which it appears to conform to the results of tests as they have been summarized by other writers. For reasons which appear later in this discussion, the detailed comparison of the results given by this formula with definite individual tests must be deferred to a future article.

In this discussion the following symbols will be used to represent the mathematical relations existing amongst the several terms involved:

- P = the total load carried, in pounds
- A = the area of cross section, in square inches
- ρ = the least radius of gyration, in inches
- l = the length of the column, in inches
- m = a factor representing the end condition

E = modulus of elasticity of the material

p_c = the yield point stress of the material, in pounds per square inch

p' = the average stress, in pounds per square inch

p = the maximum stress in extreme fibers, in pounds per square inch

$k = \frac{p_c l^2}{m \pi^2 E}$ a constant for any column of a known length, material and end condition

$\frac{p'}{p}$ = stress ratio. This ratio is constant for any given column, so long as no stress exceeds the proportional limit and is essentially constant for stress up to the elastic limit of the material.

$\frac{k}{l^2}$ = flexure ratio (tendency to buckle), as given by the theoretical deductions of Euler.

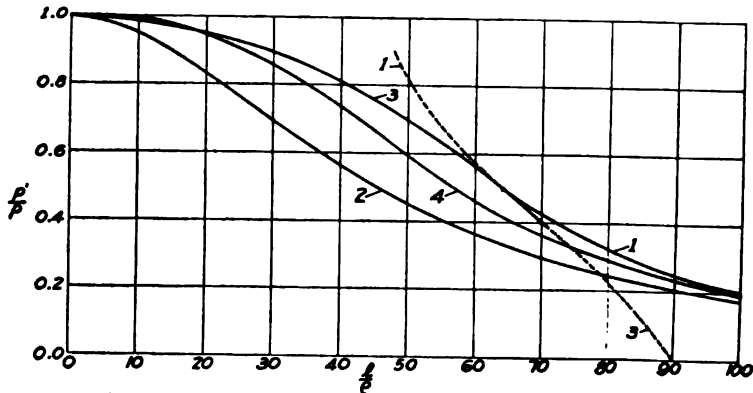


FIG. 1-4 ROUND STEEL COLUMN; $p_c = 36,000$; $p = 10,000$; $E = 33,000,000$; $m = \frac{1}{4}$

When a compression member is short, the compressive load may be assumed, without appreciable error, to be uniformly distributed over the cross section of the member, and that

$$p = p' = \frac{P}{A}, \text{ or } \frac{p'}{p} = \frac{1}{1}$$

This relation is frequently given as satisfactory for a member whose length does not exceed six times its least diameter, or for a member whose slenderness ratio (length divided by least

radius of gyration) does not exceed twenty-five. As the slenderness ratio increases there develops a tendency for the member to buckle, or to bend sidewise out of line with the load P , and to cause this load to be unequally distributed over

the cross section of the member. For all such cases $\frac{P'}{P}$ is less than unity, and the most difficult problem of the designer is to establish the true value of the stress ratio for the column in question.

This tendency to bend sideways may be due to any or all of various causes which are beyond the scope of this discussion. In general, they are individually indeterminate in magnitude so

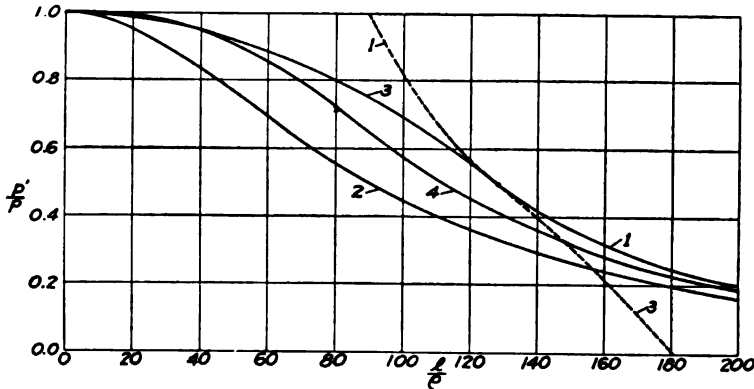


FIG. 2 - 4" ROUND STEEL COLUMN; $p_c = 36,000$; $p = 10,000$; $E = 30,000,000$; $m = 1$

that it is necessary to consider their combined effect. The first theoretical consideration of this problem was that of Euler. The formula which he developed provided only for the stress due to the tendency to buckle and did not include any additional stress due to direct compression. Solution by the Euler formula gives

$$\frac{P'}{P} = \frac{m\pi^2 E \rho^2}{p_c l^2} = \frac{l}{\frac{k}{\rho^2}} \quad (\text{Curve 1})$$

Owing to the neglect of stress due to direct compression the

value of the stress ratio, always too high in a mathematical sense, becomes increasingly so, as the length, and therefore the flexure ratio, becomes smaller. As the true value of the stress ratio is unknown the magnitude of the error is equally indeterminate. J. B. Johnson states that for columns having fixed ends this error becomes too great for safety with slenderness ratios less than 200, and for columns with round or pin ends with slenderness ratios less than 150. At slenderness ratios not much less than these values the stress ratio becomes greater than unity, which is an absurdity. This is shown by

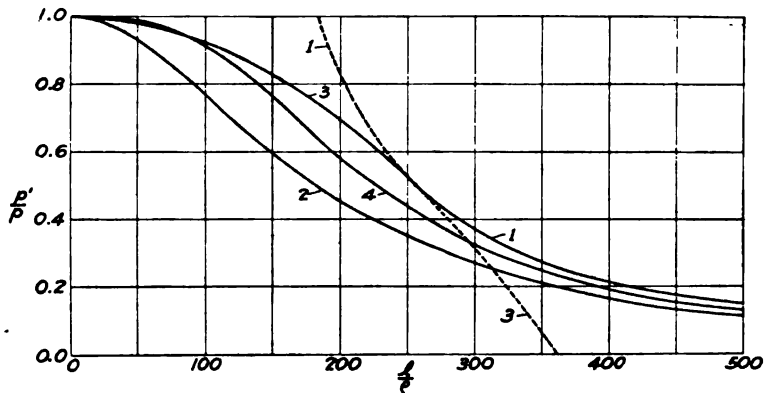


FIG. 3 - 4" ROUND STEEL COLUMN; $p_r=36,000$; $p=10,000$; $E=30,000,000$; $m=4$

Curve 1 of Figures 2, 3, 5, and 6, which have been plotted for columns of mild steel and of timber.

In an attempt to develop a formula which should give a theoretically correct value for the stress ratio, Ritter, in 1873, followed the usual practice for beams of algebraically adding the stress due to direct compression, or tension, to the stress due to flexure. In his formula (later derived independently by Merriman) he added the stress due to direct compression to the stress given by Euler as due to buckling. The stress ratio as given by Ritter's formula is

$$\frac{p'}{p} = \frac{1}{1 + \frac{k}{\phi^2}} \quad (\text{Curve 2})$$

Its value, plotted for mild steel and timber columns of various slenderness ratios, are shown by curves 2 in Figures 2, 3, 5, and 6. They start from unity at zero slenderness and approach the values given by Euler's formula as the slenderness becomes great. At all phases the values are reasonable and because of its seeming universal applicability the Ritter formula came to be much used in design. Later, however, a comparison of the failure loads for tested columns with the loads predicted by the use of Ritter's formula has led many engineers to believe that this stress ratio is too low, or in other words, that the maximum fibre stress is actually less than computed by adding

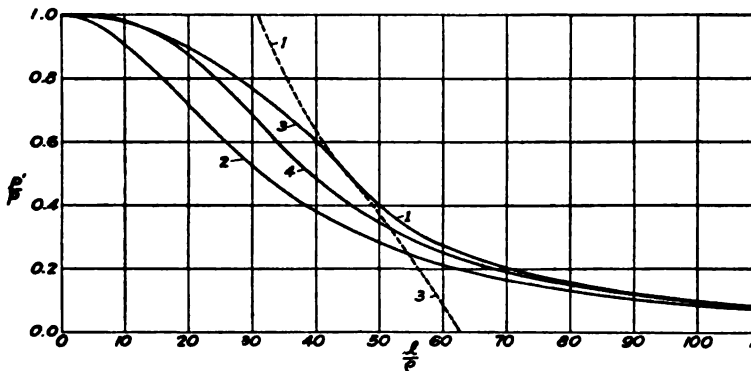


FIG. 4 - 6" SQUARE TIMBER COLUMN; $R=2,500$; $p=500$; $E=1,000,000$; $m=\frac{1}{4}$

to the direct compressive stress the full amount of stress due to buckling as given by Euler. For the moment it will be assumed that this belief is correct.

Acting upon the assumption that the stress ratio given by Ritter's formula is too low, Professor J. B. Johnson devised a formula, empirical in character, in which the stress ratio is arbitrarily taken as unity minus one-fourth the flexure ratio, or

$$\frac{p'}{p} = 1 - \frac{k}{40^2} \quad (\text{Curve 3})$$

This is the equation of a vertical parabola which is tangent to Euler's curve at a stress ratio of 0.500 and which has its vertex

at unity for zero slenderness. The parabolic form of Johnson's curve makes it impossible for it to be theoretically correct at more than three points and it rapidly becomes absurd as the slenderness ratio is increased. Its usefulness depends upon its rather close conformity to the results of column tests lying within that range of slenderness ratios most common in column design, and to its becoming tangent to Euler's curve before its values have become visibly absurd. Euler's equation is used for all values of slenderness ratio in excess of those at this

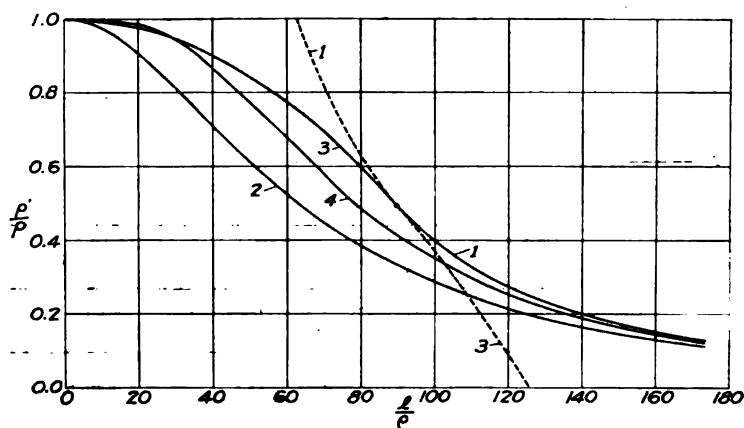


FIG. 5 - 6" SQUARE TIMBER COLUMN; $p_c = 2,500$; $p = 500$; $E = 1,000,000$; $m = 1$

point of tangency. The Johnson parabola has been plotted as curve 3 in Figures 2, 3, 5, and 6. As this curve is never

used for values of $\frac{p'}{p}$ less than 0.5 it has been shown dotted

below that point. For a similar reason the Euler curve has been shown dotted above this point of tangency.

Beyond any doubt Euler's formula gives values for the stress ratio that are too high in all cases where the flexure ratio is not too great to permit any appreciable resistance of the column against buckling. As has already been stated, Professor Johnson has set the limits of slenderness ratios below which he considers that Euler's formula should not be used as

200 for fixed ended columns and 150 for round end or pin ended columns. No value was set for other end conditions. Reference to Figure 3, plotted for a steel column with fixed ends, shows the tangency at a slenderness ratio of 256, a value which would appear satisfactory relative to Johnson's limit. The pin-ended column of Figure 2 shows the tangency at 128, well below the safe limit of 150 for Euler's formula. The column of Figure 1 has one end only fixed (as a telephone pole), and shows the tangency at 64. For columns of timber under the same end conditions the tangencies are found in Figures 6, 5, and 4, to occur at slenderness ratios of 176, 88,

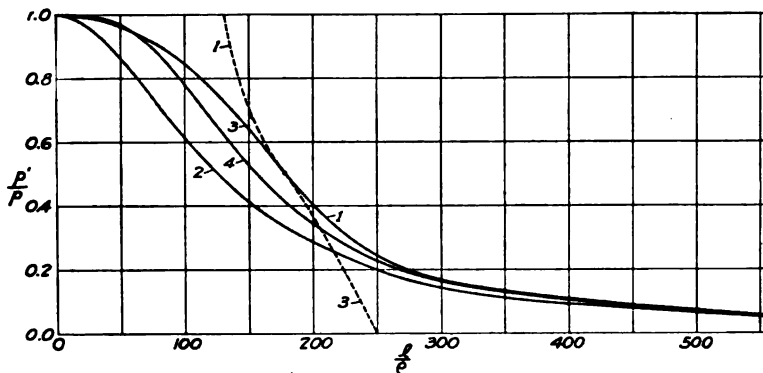


FIG. 6 - 6" SQUARE TIMBER COLUMN; $P_c = 2,500$; $p = 500$; $E = 1,000,000$; $m = 4$

and 44 respectively, far below the safety limits already set. It is very hard to believe that the effect of direct compression in the column can be entirely ignored down to any such low values of the slenderness ratio with satisfactory results. If Euler's formula gives values of the stress ratio at the point of tangency which are too high for safety, then Johnson's formula is equally in error at that point and must continue to give excessive values of the stress ratio until far enough below the tangency for the curve to have corrected itself. Nevertheless, the pressure of competition for more economical design has forced the rather extended adoption of this combination formula.

The purpose of this modification for Ritter's formula is

to retain its fundamental characteristics of applicability to columns of any material, end condition, and length, while raising the values of the stress ratio to accord more nearly with results of column tests in that range of slenderness ratios most in use, but at the same time, to avoid those excessive values of the stress ratio given by the Johnson-Euler combination in the region of their tangency. The proposed modification consists in reducing the amount of stress due to the buckling tendency which is added to the direct compressive stress, by means of a variable empirical coefficient X which is a function of the flexure ratio. This coefficient is

$$X = \frac{\frac{k}{\rho^3} + 0.1}{\frac{k}{\rho^2} + 1}$$

Its value is very small at low values of the slenderness ratio, thus reducing the effect of flexure to about one-tenth that given by Euler, but it increases, approaching unity as the slenderness ratio approaches infinity. The stress ratio is then represented by the expression

$$\frac{p'}{p} = \frac{1}{1 + X \frac{k}{\rho^2}} \quad (\text{Curve 4})$$

With the value of the flexure ratio already computed, as it must be for the application of any of these formulas, the

numerical value of the term $X \frac{k}{\rho^2}$ is given by a single setting

of the slide rule, so that there is no appreciable increase in the labor of solution over that for the unmodified Ritter formula.

For the purpose of comparison the stress ratio for the steel and timber columns of Figures 1-6 inclusive have been computed by the Modified Ritter formula and plotted beside those given by the Euler, Johnson and Ritter formulas. In

each case the relative characteristics of the several curves are the same. For the very low values of the slenderness ratio, where solution for direct compressive stress alone is considered entirely satisfactory, the stress ratios from the Modified Ritter formula are higher than from either the Ritter or Johnson formulas. Later this curve crosses the Johnson curve but holds fairly close to it until beyond that range of slenderness ratios most commonly in use for columns in practice. For steel columns with fixed ends, Figure 3, there is close agreement between the Johnson and the Modified Ritter formulas until the slenderness ratios are well in excess of 100. The greatest deviation from the Johnson-Euler combination occurs near their point of tangency where it is certain that they are each in error to an appreciable degree. The curves of Euler, Ritter and the Modified Ritter rapidly approach each other as the slenderness ratios become large, and become mutually tangent at infinity.

Thus far it has been assumed that the conclusions drawn from the results of tests of columns, which tend to show higher values of the stress ratio than those given by the Ritter formula, are fully justified. Attempts to verify this justification have been difficult for several reasons. Practically all of the test data examined have been for failure loads and failure stress ratios. For long slender columns these appear to agree fairly well with ratios computed for loads within the elastic limit. The fact remains, however, that the elastic laws which govern these stress ratios are entirely altered when any portion of the material is stressed beyond its elastic limit. The effect of this change of law is to cause the tested column to appear to have carried a much higher stress ratio than was true at any time within the elastic limit. This may account for the tendency to accept higher values as being justified by the tests. Some of the recent data from the tests of large bridge columns are complete for computing both stress ratios and flexure ratios but these all fall within that lower range of flexure ratios and slenderness ratios for which all of these formulas are in practical agreement.

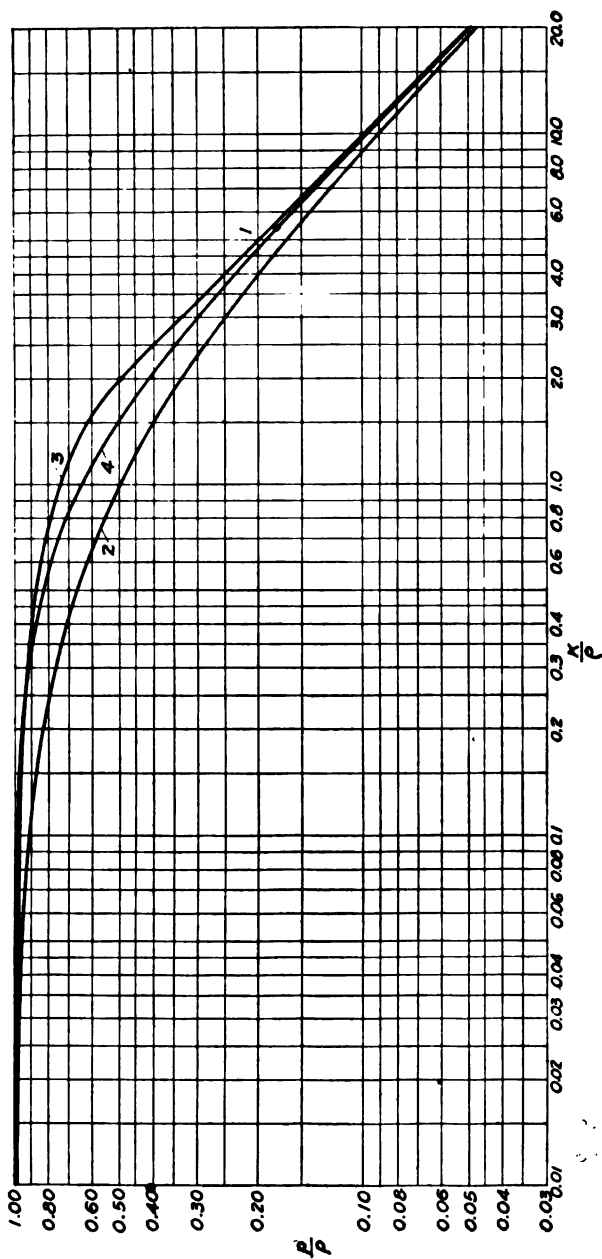


FIG. 7

Comparison of results has been further hampered by the established practice of plotting stresses and stress ratios as ordinates against the slenderness ratios as abscissas. On this basis the curve for each of the column formulas assumes a different position for each change in material, end condition or length. Comparison of general results required the computation and tabulation of individual values instead of checking with points on a fixed curve. For each of these formulas the stress ratio is a function of the flexure ratio instead of the slenderness ratio. When plotted with the flexure ratio as abscissas each formula gives but a single curve regardless of material, end condition, or length. If the value of the flexure ratio is computed for each column tested and the stress ratios plotted on such a diagram, an instantaneous comparison is had simultaneously with each of the column formulas. The values, however, of the flexure ratios are such that they do not plot readily on standard cross section papers, which may in some measure explain why they have not been used as abscissas. Fortunately these curves are easily plotted on the logarithmic paper and are shown in Figure 7. The curve for Euler's formula which was a rectangular hyperbola is now a straight line with a slope of 45 degrees, to which the Johnson curve is tangent at the point whose coordinates are 2 and 0.5. The Ritter and Modified Ritter formulas each give curves asymptotic to the unity stress ratio line and to the Euler 45 degree line.

It is not possible at this time to present proof of any superior accuracy for the Modified Ritter formula. It is believed, however, that the following facts will make it a valuable formula for the use of the designers engaged with general problems.

- a. In its results it lies between two such well established formulas as those of Ritter and Johnson.
- b. It lies close to each at those points where their results are best established for accuracy.
- c. It differs in the right direction from each of them at those points where their results are most in doubt.
- d. It is applicable throughout all ranges of slenderness ratios.
- e. It is applicable to all materials and end conditions.
- f. It is readily solved by use of the slide rule alone.

RIVER CLAYS AND THE PLEISTOCENE PROBLEMS
IN WEST VIRGINIA¹

By JOHN L. TILTON.

CONTENTS.

The presence of Pleistocene clays along the Monongahela has long been known. This paper calls attention to lamination, (not varves) and reviews what is known of local Pleistocene history.

ACKNOWLEDGEMENTS

In addition to the references cited the writer wishes to acknowledge the valuable criticism of Professor Frank Leverett, whose extensive glacial work in the region here considered and farther west is well known.

The so-called "river clays" of West Virginia belong to two separate groups: those which are brought in by streams and deposited along the present valley floors, and those which as silt were deposited when Pleistocene ice or deposits of glacial gravel blocked the drainage north. One of the lakes formed Dr. I. C. White called Lake Monongahela, since it lay along the valley of Monongahela River and at one time had outlets in three or four cols near Salem, West Virginia. Along an old course of the Kanawha are deposits early referred to a "Lake Kanawha" (Teays Valley).²

Thus along Lake Monongahela water loaded with silt from tributaries and blocked by glacial gravel further north gently deposited its load forming what are now high terraces along the valley. On melting of the ice drainage northward to Pittsburgh was reestablished, from which place the water flowed along what is now the Ohio, the earlier drainage northward toward what is now Lake Erie having been closed first by an earlier ice sheet and then by deposits left by that ice sheet. The region has since been eroded so that the gravels

¹Published by permission of the West Virginia Geological and Economic Survey. Laminated clay was exhibited by the writer at the meeting of the West Virginia University Scientific Society January 24, 1930.

²See West Virginia Geological Survey, Vol. 3, 1906, pp. 258-260; also Huntington Folio No. 69 of the Geologic Atlas, 1910.

of those old stream beds may now be seen 200 to 300 feet above the present river.³

The above has been known for a long time—since 1883, especially since 1896.

The Clay. The clay here exhibited was obtained a few yards west of the cement bridge on the road from Morgantown to Star City. On the surface the clay presents a uniformly brownish-yellow color both at the place where it was obtained and along the flat in that locality to a height of about twenty feet. A little to the north a low knoll contains a yellowish-gray weathered shale.

On removing the surface mixture the clay is seen to be light-gray in color, lower portion almost white, divided horizontally by thin bands stained yellowish-brown by iron oxide (limonite) that fades slightly at the upper margin of each band. The topmost portion immediately beneath the loose slumped material at the surface is more deeply and irregularly stained than what is below, as if more affected by recent oxidation. Six centimeters beneath the top oxidized band is the second band where the most discolored portion is about a centimeter thick. It is six centimeters to the third band of iron staining, which is here one and a half centimeters thick. Five centimeters further down through clay with an almost white color is the center of a slightly yellowish band three centimeters deep. The clay tends to part irregularly at this layer. Five centimeters deeper is a faint band of light brown about half a centimeter thick, though the discoloration is spread faintly over three centimeters. As the clay was removed it broke irregularly along this plane. Another six centimeters reaches the bottom of the clay obtained, at apparently another brownish-yellow band. On cutting farther back into the clay or silt it was found that the spacings of the brownish bands of iron oxide do not remain constant, as revealed on comparing the above records. On cutting about a foot still

³"Transported clays" are considered on pages 644-646 of the West Virginia Geological Survey on Doddridge and Harrison counties, and on pages 755-756 of the report on Marion, Monongalia and Taylor counties.

further back the regularity of banding disappeared, the iron oxide occurring chiefly in two large patches. With such a relation measurement was not thought worth while. It appear-

The lamination as seen immediately beneath the surface mixture.		The lamination as seen after cutting perhaps six inches farther back into the clay.	
Reddish-brown.	Light-gray	Reddish-brown.	Light-gray
	6 cm.		
1 cm.	6 cm.		} 11 cm.
1.5 cm.	5 cm.		
3 cm.	6 cm.	2.5 cm.	8 cm.
3 cm.	5 cm.	5 cm.	

ed evident that the lamination here was due to creep. Places where iron oxide was abundant becoming moistened by the rains had become gliding planes which became more and more distinct toward the surface and then were lost in the surface mixture even in the place selected where it was thought that creep would be least likely to occur.

Some of the high level terrace clays along the Monongahela are described as laminated, but it is not known whether all such clays are laminated. A sample from the col a mile west of Salem, West Virginia, presents the same general appearance as the sample obtained near Morgantown, but the sample at hand from near Salem is too small to be satisfactory.

Dr. I. C. White described a section the base of which is 912 feet above tide at the mouth of Dunkard Creek, stating that it is like that found at Geneva and Greensboro where it is used as a potters clay, and like that found 150 feet above the river on Miller's farm, West Morgantown, where it is at 943 feet above sea level. The description⁴ is as follows:—

⁴I. C. White: "Origin of High Terrace Deposits of the Monongahela River." Am. Geol., Vol. 16, p. 370. 1896.

	Feet
1. Rounded boulders, and river wash	50
2. Soil, boulders, etc., to top of clay bed	5
3. Reddish clay, fine, tough	10
4. Clay mixed with sand, and brown iron ore	6
5. Bluish-gray clay, fine, tough	10
6. Bed rock to level of Monongahela river (which water is • here at 772 feet above sea level)	140
Total	221

Dr. I. C. White's section at the mouth of Dunkard Creek.

Apparently this section may be read as follows:—

- Nos. 1 and 2. Coarse gravel (cobbles).
- No. 3. Silt.
- No. 4. Coarse gravel, cemented with iron oxide.
- No. 5. Silt.

Are there laminations in both Nos. 3 and 5? What is the significance of the No. 4 parting?

The clays at 980 feet above sea level near Carmichaels, Pa., are distinctly described as laminated clays⁵, and a section of strata from the excavation for the "Cathedral of Learning" preserved in Carnegie Museum is somewhat laminated and similar to that found at "The Flats" on the road from Morgantown to Star City. The section preserved in Carnegie Museum has two distinct beds of clay with sand between:—

	Feet
Clay	4
Sand	4-½
Clay	3-½
Sand	3
Sandy clay	1
Gravel	2-½
Total	18-½

Section preserved in Carnegie Museum.

Such relations in a valley the drainage of which has been blocked by ice during glacial times raises the question whether

⁵Geological Atlas, Masontown-Uniontown Folio No. 82. 1902.

varves are to be found anywhere in the valley, such as are found farther north in lakes south of melting ice sheets; but the character of the clays seen at "The Flats," and the character of those preserved at Carnegie Museum do not favor such a possibility. Nevertheless, the distribution and minute character of these high-level terrace clays along the Monongahela valley deserve a careful study. Their relation to the entire Pleistocene problem for this part of the country is such that a further review of the subject is here presented.

Glacial Problems in Their Relation to West Virginia.

What are Varves? A varve is a banding in lake clays due to seasonal variation in sedimentation. Such bandings were noted in clays of the Connecticut River valley by Edward Hitchcock in 1841, who correctly judged them due to seasonal variations. Varves in Sweden were studied by Gerard De Geer chiefly in 1905-6, but beginning as far back as 1879, and the method of using them pointed out. In the summer of 1927 the succession of varves was completed up to the present ice front along the Angerman River in Sweden by R. Liden and announcement made by De Geer in "Science" of November 11, 1927, that the number of varves formed in the lakes from the time the ice at that point began to melt back to the present time was 8,700, which thus indicates the time that has elapsed since the retreat of the last ice sheet—the best determination of this important unit of time that we have.

In 1920 De Geer came to America accompanied by Dr. Ernst Antevs and began the study of clays in the glacial lake beds of America. Since his return to Sweden Dr. Antevs⁶ has continued the work, aided by others. A complete series is not yet found in America, and difficulty has been experienced in distinguishing between varved clays formed off older ice sheets⁷ and those formed off the last ice sheet as it melted away.

⁶Antevs' methods and results may be found described in the Canadian Geological Survey Memoir 146, 1925, and in the American Geological Society Research Series No. 11, 1922 and No. 17, 1928.

⁷A. P. Coleman: "Long Range Correlation in Varves." *J. of Geol.*, Vol. 27, 1929, pp. 783-789.

The deposits of silt⁸ in a lake vary with the season. As spring and summer come on the water from melting snow washes out exposed soil and clay, and transports it to lower levels, toward the ocean now, toward lakes in the time that we are considering. In late summer and early winter the lessening flow transports less material, in which there is less carbonaceous matter and more clay than when erosion is vigorous. Such clays are banded, dark gray and light gray. This is the character of the varved clay found in the lake beds in front of the last ice sheet, upon which De Geer worked. Here in West Virginia the seasonal conditions are somewhat different. While lamination may be caused by varying conditions in the year, the type that elsewhere has especially attracted attention is associated with the melting of ice sheets, hence glacial. Are any of the silts along the Monongahela varved? They are recognized as formed in slack water when the valley was blocked by ice and ice deposits. If there are true varves and well enough preserved they afford a means for determining the actual number of years during which the valley was flooded.

Early Discussions with reference to the Kanawha and the Ohio. The early recognition of glaciation (1850) was followed by the recognition of two main divisions in the deposits (1872), and later by the recognition of five, with interglacial deposits between. The five glacial stages are as follows, oldest at the bottom, and interglacial stages between:

- Post-glacial or Present.
- 5. Wisconsin Glacial Stage.
- Peorian Interglacial Stage.
- 4. Iowan Glacial Stage.⁹
- Sangamon Interglacial Stage.

⁸W. H. Twenhofel: "Treatise on Sedimentation," 1926, pp. 190-193. More complete discussions are to be found in the reports of the Committee on Sedimentation, 1926, pp. 4, 66 and 68; and 1927, pp. 42-59.

⁹Professor Frank Leverett considers the Iowan as probably correlative of the Illinoian and thus recognizes only four glacial stages. See "Problems of the Glacialist," Science Vol. 71, Jan. 17, 1930, pp. 47-57; also, "Relative Length of Pleistocene Glacial and Interglacial Stages," Science, Vol. 72, Aug. 22, 1930, pp. 193-195.

3. Illinoian Glacial Stage.
Yarmouth Interglacial Stage.
2. Kansan Glacial Stage.
Afton Interglacial Stage.
1. Nebraskan Glacial Stage.¹⁰

On advance of the ice the old drainage lines to the north were buried and drainage along the front turned westward, the streams gradually cutting through the divides till the present drainage line of the Ohio was marked out.

In the time (late Tertiary) immediately preceding the spread of the Pleistocene ice sheets the area of New River was extended eastward as far as the Piedmont area and, on evidence that Leverett and others have presented, flowed northward past Waverly¹¹, Ohio, at a time when there was a divide at Manchester, farther down, that is now crossed by the Ohio. When the col at this place was cut through a lower line of drainage was developed past Point Pleasant, thus draining Teays Valley. Thus the deepest cutting in Teays Valley and the deposition of the lowest sand and gravel below the silt are referred to the late Tertiary, and the deposition of clay in that valley is referred to the time of the earliest (Nebraskan) Pleistocene ice sheet.¹²

The advance of the first ice sheet (Nebraskan) closed drainage to the north. On its retreat drainage northward may have been reestablished at least in part. Such drainage as was reestablished northward was closed again on the Illinoian ice

¹⁰It is not yet decided whether an old glacial deposit in New Jersey, called Jerseyan, represents the Kansan or the Nebraskan.

¹¹Monograph 41, U. S. G. S., 1902, pp. 104-109.

Teays Valley is described in Wright's "Glacial Boundary in Western Pennsylvania, Ohio," etc., 1884, pp. 86-87, and in Bulletin 58, U. S. G. S., 1890. In the Huntington Folio No. 69, 1900, is the following: "It seems probable that it was formed by the accumulation of floating river ice borne down by the water of Kanawha River," rather than by a glacial dam in the Ohio (near Cincinnati). On this supposition clay, sand and gravel are all referred to the early Pleistocene. It is also considered in the Charleston Folio No. 72, 1901. The valley and drainage changes are fully described by W. C. Tipton in Professional Paper No. 13, 1903, pp. 50-57. The valley is mentioned on pages 259-260 and 264-266 of Vol. 3 of the West Virginia Geological Survey, and in the survey reports on Cabell, Wayne and Lincoln counties, 1913, pp. 24-26 and 412-416.

¹²Frank Leverett: Monograph 41, U. S. G. S., 1902, pp. 90-106.

advance and remained closed from that time on. The development of the Ohio along western West Virginia was largely effected in the interglacial interval between the Kansan and the Illinoian ice sheets—the Yarmouth Interglacial Interval. The evidence of an old late Tertiary divide near New Martinsville and later early Quarternary divide near Moundsville as suggested by Chamberlain and Leverett¹³ is fully described by Leverett on pages 88-94 of Monograph 41, published in 1902. In that region old preglacial rock terraces and gradation planes are reported sloping downward toward the north, and streams now tributary to the Ohio are seen to turn northward as if to enter streams flowing north. The new drainage toward the south developed in this region an advantage of at least 100 feet lower level than that of the old drainage northward toward Beaver.

Along this new drainage line south Leverett¹⁴ calls attention to pre-Illinoian glacial gravel deposited at 1040 feet elevation above sealevel near East Liverpool, Ohio, sloping southward to the 1000-foot contour at Belaire, Ohio. He also calls attention to lower level of terraces along the valleys at 1000 feet near Pittsburgh, 960 at the mouth of Beaver, over 900 feet at East Liverpool and, much farther southward, about 800 at Moundsville. The gravels at this last or lower level he finds are Illinoian in age, and the latest main cause of ponding the Monongahela Valley. Thus the high-level clays along the Monongahela are not later than Illinoian.¹⁵

In the West Virginia Geological and Economic Survey reports on Jackson, Mason and Putnam counties, p. 341, reference is made to glacial material brought down the Ohio. In the reports on Marshall, Wetzel and Tyler, p. 620, and on Ohio, Brooke and Hancock counties, p. 362, Wheeling Fine

¹³T. C. Chamberlain and Frank Leverett: "Studies of the Drainage Features of the Upper Ohio Basin." *Am. Jour. of Sci.*, 3rd Series, Vol. 47, 1894, p. 253.

¹⁴Personal communication.

¹⁵An excellent bibliography up to 1902 may be found on pages 28-49, Monograph 41, U. S. G. S. On pages 88-100 Leverett discusses the Upper Ohio or Old Monongahela System, and on pages 100-108 he discusses the Middle Ohio and Old Kanawha Systems.

Sand is not mentioned, but the reports recognize a gravelly and sandy phase of the loam.¹⁶

Early Discussions with reference to the Monongahela. The early discussions as the study of the region progressed are certainly of interest. Such discussion so far as it relates to Teays Valley, the Kanawha, and that part of the Ohio along the western border of West Virginia has already been given. There is more with reference to the Monongahela, touching also upon conditions along the Ohio.

As early as 1883 Dr. I. C. White¹⁷ had contributed a description of the distribution of terraces along the Monongahela and some of its tributaries. At the Forty-fifth Meeting of the American Association for the Advancement of Science (Section E) held at Buffalo, August 22-29, 1896, Dr. I. C. White accepted Chamberlain's suggestion, "that there was a col south of Wheeling to be cut down, and it is thought to have been sufficiently high at first to form the barrier that dammed the water up to the level of the Monongahela terraces," and added that, "a Cincinnati ice dam - - may have been influential to produce terraces farther down the valley." This is published in "The American Geologist," Vol. 18, 1896, p. 227. In the full text of the paper which appears on page 368 of the same volume, he refers to an earlier paper that he presented at the Minneapolis meeting of the American Association (A. A. A. S.) in 1883, and also states that the paper published in full, p. 368, is the paper that he read at the Buffalo Meeting in August, 1896. In that paper he describes the distribution of these clays along the Monongahela River in

¹⁶See also, John L. Tilton: "Two Illustrations of Wind Action in West Virginia." Proc. W. Va. Acad. Sci., Vol. 2, p. 145. 1928.

¹⁷In his paper read at Minneapolis in 1883, Dr. White recognizes five terraces near Morgantown, the lowest of which is at 820 feet above tide and the highest, the fifth, is at 1065 feet above tide, as seen at "the flats." Two of the intermediate terraces are evidently those on which the postoffice and the university are located. This paper is quoted by G. F. Wright in "Detailed Report of Investigations along the Boundary of the Glaciated Area in Ohio and Indiana," Appendix. Western Reserve and Northern Ohio Historical Society, Vol. 2, 1884, Tract No. 60, pp. 273-278. Dr. White's paper in the American Journal of Science, 3rd Series, Vol. 34, 1887, p. 375, is quoted by G. F. Wright in Bull. 58, U. S. G. S., p. 84.

both West Virginia and Pennsylvania, and traces them past Pittsburgh and Beaver to the moraine above that place. The text (p. 370) makes it appear that Dr. White thought the barrier that dammed the water was the Wisconsin ice sheet. Dr. White distinctly describes the earlier bed of the Monongahela River, on which the high Pleistocene gravel and clay here considered lie, as preglacial. He recognizes thick beds of

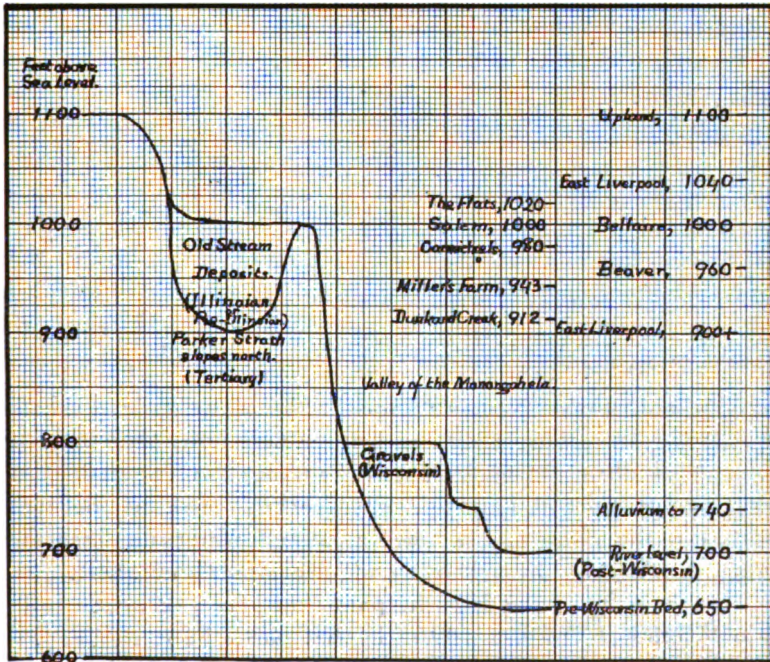


Fig. 1.—Various Levels Mentioned in this Paper.

When the Tertiary valley of the Monongahela was clogged with "old stream deposits" the water began to flow over low places in the divides. On later uplift the Monongahela trenched its meanders along this new course to a depth of fifty feet below the present level of the stream. In Wisconsin time this valley was partially filled with sand and gravel, in which the river has since cut its present trench.

gravel that he included in his "Morgantown Beds," and also recognizes beds of silt. He considers the gravels contemporaneous with the silt, or immediately following it.

In the Masontown-Uniontown Folio No. 82 (1899) the silting of the old river channel is considered to be local and at different points. Laminated clay is reported near Carmichaels, at 980 feet above tide. In the Burgettstown-Carnegie Folio No. 177 (1911)¹⁸ abandoned preglacial channels are traced northward toward the Lake Erie region. The filling of the old channels is considered Kansan¹⁹, following which streams left clogged valleys and flowed through cols, thus establishing the line of present drainage in pre-Illinoian time (Yarmouth time). In the erosion that followed, the streams cut channels that are fifty feet below the present channels, entrenching their meanders, cutting farther on the outside of the bends and forming "slip-offs" on the inside of the bends. In Wisconsin time gravels to the depth of 150 feet were deposited in these channels, in which gravels the streams have since cut their channels 100 feet to their present level, and in that process developed terraces at various heights one of which is 40 feet above the present stream level as seen at Morgantown, the terrace on which the railroads have been built.

In the present writer's thought the development of the main terraces along the Monongahela thus correlates with the development of Pleistocene terraces along the Potomac (Earlier and Later Columbia). They are thus referred to causes affecting the whole region, deposition followed by uplift rather than followed by stream erosion independently of uplift.

Striated Pebbles. The prospects of finding evidence of glaciation in the mountains of West Virginia, Virginia, Kentucky, Tennessee, and North Carolina have been slight. Striated pebbles have been found in the terrace gravels along the

¹⁸See B. C. Jillson: "River Terraces in and Around Pittsburgh," *Trans. Acad. Sci. and Arts of Pittsburgh*, 1873. This paper and another by the same author were republished in 1920. He recognizes four terraces near Pittsburgh. See also Henry Leighton: "The Geology of Pittsburgh and its Environs: a Popular Account of the General Geologic Features of the Regions," *Annals of the Carnegie Museum*, Vol. 17, 1926, pp. 91-166. This has been published as a separate booklet that can be obtained at Carnegie Museum.

¹⁹Frank Leverett at present says "not later than Illinoian." We await final decision on this point.

Potomac as far up the stream as Cumberland²⁰, and in the stream gravels of Kentucky, Tennessee and North Carolina. Their presence is thought due to vigorous ice action along streams, for no conclusive evidence of local glaciation along the mountains has been found²¹. In our own immediate locality (Morgantown) the chance of discovering striated pebbles in the terrace gravels does not appear promising, for apparently, even if there were local glaciation in spots, or if there were vigorous ice action along the streams, Cheat River cut off transportation from farther east throughout Pleistocene time.

²⁰G. K. Wentworth: "Striated Cobbles in Southern States." Bull. Geol. Soc. Am., Vol. 39, 1928, pp 941-954. Dr. I. C. White mentioned rounded boulders as existing at high altitudes along New River, the Potomac and the Monongahela but he did not record them as striated. "Rounded Boulders at High Altitudes along some Appalachian Rivers," Am. J. Sci., series 3, Vol. 34, 1887, pp. 374-381.

²¹Under date of February 28, 1930, Dr. William C. Alden writes as follows: "Such of Wentworth's striated pebbles as I have seen look the same as glaciated pebbles. I do not, however, see how they can be considered as glacial in the situations where they were found. We have no other evidence, so far as I know, that there was any glacier ice in the basins of the Potomac or other rivers farther south. For the present, at least, I regard the striae as the work of heavy, Pleistocene, river ice."

In "Science" of May 9, 1930 (Vol. 71, p. 483) Julian J. Petty calls attention to "Striated Cobbles from Teay Valley, West Virginia," and states that a more detailed description "will be published elsewhere."

BULLETIN OF THE
DEVELOPMENTS IN THE TREATMENT OF ACID
MINE DRAINAGE

By LEWIS V. CARPENTER,
Professor of Sanitary Engineering, and

ALFRED H. DAVIDSON,
Fellow in Sanitary Engineering,
West Virginia University.

Since the World War the State of West Virginia has forged ahead rapidly in the production of bituminous coal and at the present time the leadership in production is shared with Pennsylvania. West Virginia coal is a high grade coal and ranks with the best for steam purposes. Most of the veins are high in sulphur and the use of this coal for by-product purposes has been held back on account of the high sulphur content of the coke, making it unsuitable for blast furnace purposes.

ACID MINE WATER

The drainage from coal mines has become an acute problem in West Virginia due to the acidity of the water. The results of a number of weir measurements made on the discharge from mines in Northern West Virginia and Western Pennsylvania indicate that the quantity of drainage will equal about twenty-five percent of the rainfall which is the estimated penetration. This figure is based on the area of coal exhausted. The quantity of drainage is dependent on the thickness of the coal vein, the character of the roof, thickness of the cover, character of surface topography, method of mining (pillars drawn), daily tonnage, and the area of coal exhausted. The last seems to be the best criterion of comparison and for the ordinary year in West Virginia (1) the average quantity of water will be about 1000 gallons per day per acre of coal exhausted. This is a pertinent fact because the quantity of mine drainage is increasing directly with the mining of coal. The flow of water (2) does not fluctuate with the rainfall to any great extent as the majority of the deep mines will pump nearly as much water in the dry season as in the wet season.

ACIDITY OF MINE WASTE WATERS

Unfortunately it is not always possible to predict the acidity of the mine drainage from the vein of coal or even particular localities. Two mines within a few miles of each other may produce entirely different kinds of drainage from the same vein of coal. One of these mines which will be identified as mine A produces about 200,000 gallons per day of water which has an alkalinity of 170 p. p. m., while mine B, less than three miles away, mining from the same vein (Sewickley) produces 130,000 gallons of water with an acidity of about 30,000 p. p. m. The analysis of coal reported from Mine A showed 3.0% sulphur and Mine B 2.6%. Numerous tests failed to reveal any direct relation between the sulphur in the coal and the acidity of the drainage. The same holds true of the coal veins. During a survey made during the summer of 1929 (3) the drainage from mines in the Freeport vein had a pH value from 2.1 to 6.8, the Pittsburgh vein from 1.8 to 6.8, and the Sewickley vein from 1.8 to 7.6. Analysis of the water showed that some drainage was distinctly alkaline while others were very acid. (One sample was 69,700 p. p. m.) Table I is the partial analysis of the water from several mines.

TABLE I.

Determination	No. 1	No. 2	No. 3	No. 4	No. 5
Total Residue	13,600	69,560	5,262	33,600	10,692
Acidity	6,980	47,800	1,375	22,700	+154
Sulphates	7,400	41,700	3,560	19,300	990
Total iron	1,530	12,270	460	5,900	14
Calcium	590	412	477	682	780
Magnesium	6	13	12	20	32
pH value	2.6	1.4	2.9	2.0	7.2

EFFECTS OF ACID MINE WATERS

Acid mine water is very detrimental to our streams. It makes the water corrosive, unpalatable and unsuitable for domestic, commercial or recreational purposes. It is felt that it has a very marked effect on fish life, but this subject needs a large amount of investigation to work out just what concen-

tration of mine water that will permit propagation of fish life.

TREATMENT OF ACID MINE WATERS

The largest installation for the treatment of mine drainage was built by the H. C. Frick Company at its Calumet Mine (4). The water is pumped from the mine by wooden lined pumps to concrete towers which are at an elevation sufficient to let the water pass through the plant by gravity. The water leaves the towers through baffles into mixing chambers where it is mixed with lime that will pass a No. 200 mesh screen. The lime and water are thoroughly mixed and then run into a Dorr thickener. This thickener has a retention period of four hours and the settled water flows over a weir and thence to a storage tank where it is again settled and the settled sludge is pumped on a revolving steam heated drum which evaporates a large part of the water and leaves a deposit of ferric hydrate. Ferric hydrate has a limited use in removing hydrogen sulphide from artificial gas and as a base for paints. This company has discontinued the process because of the inability to market the ferric hydrate.

Collins (5) shows the design of a treatment plant where lime is added to the acid mine water in a baffled chamber and then given a 2 to 4 hour retention period in a settling chamber. This process gives a sludge containing about 75 % water and remainder ferric hydrate. The sludge is dried by splashing against a heated drum. Collins says that about one hundred pounds of lime is required for each 1000 gallons of water. This plant was not built.

A Travers Marl clay (6) filter was installed on Elk Creek in Harrison County, West Virginia. A limy marl was added to the water after which it was allowed to settle. Press dispatches state that after this plant was installed that fish life was abundant and the stream was very much improved. This plant has since been abandoned.

A number of patents have been granted for the treatment of polluted acid waters (6). One of these processes is based

on treatment by passing the liquid waste through porous calcium carbonate and maintaining a period of contact of between two and five minutes. The writer does not know of a plant of this type that has been installed on a commercial scale.

About one year ago the West Virginia Geological Survey released a press dispatch (7) in which they announced the Kaplan-Reger process for treating mine waste waters. According to the dispatch, "it consisted in adding to the sulphate waters a complex organo-metallic compound which combines with the chemical compounds of the water and forms a blue pigment to be known as Monongahela blue and at the same time remove the acid." In conclusion the dispatch states that, "in the Kaplan-Reger process, the added chemicals combine completely with the chemicals in the water to form an insoluble, marketable product, leaving the water practically free from acid and mineral substances." This process has not been tried on a large scale and not enough technical data have been reported to properly interpret the possible results from the process.

One article (8) suggests the use of magnesite for the neutralization of mine waters. The author states that it takes about one-third as much magnesite as lime and that the magnesite can be used as a substitute for lime in a majority of the processes of neutralization of mine waters. Magnesite costs more than lime.

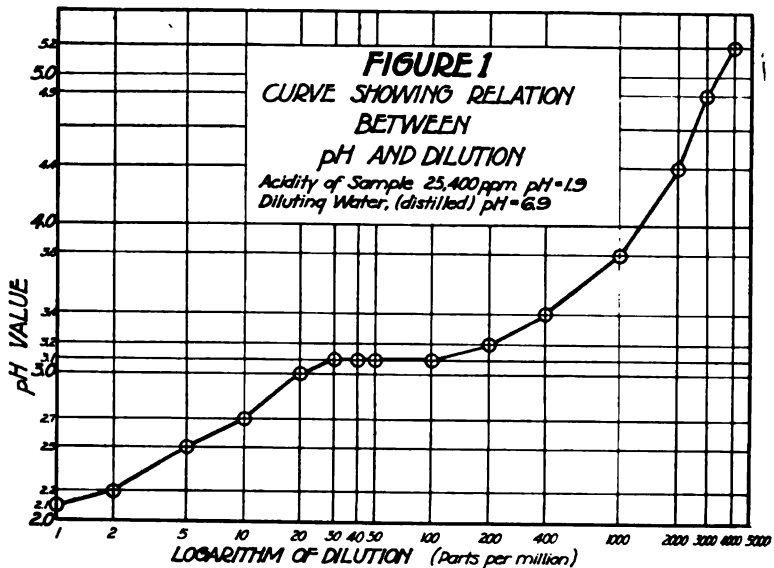
SEALING ABANDONED MINES

Unfortunately abandoned mines offer a real problem in the treatment of acid mine waters. The gobbled material both in and out of the mine cause a lot of acid water. One mine in Monongalia County which has been abandoned since 1922 is discharging over 100,000 gallons of drainage with an acidity of over 10,000 grains per gallon. (9) Leitch has suggested that most mines lend themselves readily to sealing inside the mine. He suggests a concrete slab about three feet thick and extending into the rib about the same distance as a satisfactory seal. A valve should be provided to relieve exces-

sive pressure. Several installations in Pennsylvania have been successful in the prevention of the formation of the acid water.

DISPOSAL BY DILUTION

One writer makes the statement that the dilution required for mine water should be about 1 to 120. Fig. 1 shows the relation between acidity and pH of a sample of mine water diluted with distilled water ($\text{pH}=6.9$). A dilution of 1:20



increased the pH value from 1.9 to 3.0. 1:30, 1:40, 1:50, and 1:100 dilutions all had a pH value of 3.1. In other words, an acidity of 850 p. p. m. gave the same pH value as the sample with an acidity of 254 p. p. m. A dilution of 1:4,000 brought the pH value up to 5.2. These results have been checked and bring out a point that is very important in stream pollution work, i. e., there is a range of dilutions for practically every mine water which gives the same pH value. pH values offer a better criterion of the aggressiveness of the water but in working out the assimilating power of a stream it is necessary to try diluting samples collected to see if the

pH value is for the higher or lower acidity. This set of experiments partially explains some discrepancies which occurred last summer during the pollution survey of the Cheat River. Very frequently samples of water which had been diluted by alkaline stream showed the same pH value as the stream before the addition of the diluting water.

In studying the diluting power of a stream for acid waste waters, it is necessary to develop standards. Should the stream be able to support major forms of aquatic life? If so, what pH value of water and what acidity will be the lower limit? This offers a real research problem as unfortunately nothing has been done on the resistance of fish life to mine waters. One of the authors has found black bass spawn living in sections of Lake Lynn where the pH value was less than 3.0. It is hoped to conduct some experiments during the coming summer on the effects of various concentrations of mine waste water on fish life.

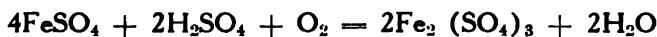
A large amount of work is necessary to work out the exact relation which exists between the acidity of the mine water and the proper dilution to avoid undesirable conditions.

ORIGIN OF ACID MINE WASTE WATER

It is generally agreed that after coal has been mined that the water passing through the coal and slate beds oxidizes the pyrites into ferrous sulphate and free sulphuric acid. These acids oxidize to hydrates which give the familiar brownish-yellow color to the bottom of streams that carry sulphur water. The following reactions indicate what is assumed to take place:



and this reaction continues as follows:



The oxidation of the pyrites is a very slow process. Winchell (10) found that on treating pyrites with aerated water for one month that neither the iron nor sulphur had gone into solution. It has also been found that alkaline waters decompose pyrites and marcasites to ferric oxide. All of these changes are rather slow and it is difficult to explain the rapid

formation of acid waters in mines by chemical theory alone.

Anaerobic bacterial action by some of the sulphur producing organisms might possibly explain some of the high acidities found in mine waste waters. The authors have started a rather exhaustive series of tests to determine whether this acid production is due to bacterial action. (11) Powell and Parr found that at the end of 88 days an innoculated coal showed a decided increase in soluble sulphur over that found in a sterilized sample. It is a well established fact that the sulphur in the coal is not soluble enough to account for the amount of sulphates found.

LABORATORY EXPERIMENTS

A series of laboratory tests were made to determine the feasibility of using various neutralizing agents for the treatment of acid mine waters. A sample of water with an acidity

TABLE II.
Data on the neutralization of 1000 gallons of acid mine water and the resultant sludge:

Neutralizing Agent.	Lbs. per 1000 gal.	Approximate volume of sludge %	Weight Dry
Lime (90 % CaO)	172.5	35	424
Pulverized limestone	434.6	35	621
Sodium hydroxide	130.0	25	188
Calcium carbonate	161.5	40	352
Sodium carbonate	200.0	40	194
Ammonium hydroxide	160.0	20	130
Sodium carbonate plus	80.0		
lime	66.3	25	...
Lime + NaOH	61.9		
	60.0	35	183
Potassium ferrocyanide*	142.3	..	264
Lime + Potas. Ferrocyanide	60.		
	103.5	..	389
Sodium Cyanide	140.	..	188

*This quantity of potassium ferrocyanide brought the pH value to 3.0 only as compared to 5.6 for the other processes.

of 22,700 p. p. m. and a pH of 2.0 was selected for the tests. The neutralizing agent was added in varying amounts until the pH value had reached 5.6. This value is high when the volume of diluted water available is appreciable but it is about the lowest limit for the support of major fish and plant life.

The quantity of sludge was measured, and its water content determined.

On a cost comparison basis it was figured that the limestone treatment would be cheaper. On the basis of capitalized cost of plant drying of sludge and no return for the sale of sludge it was figured that the total cost per 1000 gallons would be \$0.90. This treatment would neutralize the water but would not make it suitable either for domestic or industrial use on account of its hardness. It does seem to remove the majority of the iron from the water. These laboratory tests clearly indicate (as many other results have already shown) that the success of treating mine waters will not be assured until some method of utilizing by-products has been developed that will help pay the operation costs.

CONCLUSIONS:

1. That the present status of mine waste water is very uncertain and that much fundamental research is needed on the origin of the water and the formation of the acid.
2. The laws governing the amount of diluting water should be worked out.
3. Research work should be done on the effects of high sulphate waters on aquatic and animal life.

BIBLIOGRAPHY

1. Wanted: More Research on Acid Mine Waters, by Lewis V. Carpenter, *Coal Age*, Vol. 35, p. 406, July 1930.
2. Pollution in the Monongahela River Basin and Its Effect on Public Water Supplies, by Lewis V. Carpenter. *W. Va. Eng. Exper. Station Tech. Bulletin No. 2*, 1929.
3. Report on Pollution Survey of Cheat River Basin, by Lewis V. Carpenter and L. Kermit Herndon. *State Water Commission*, 1929.
4. *Coal Age*, Anon. July 1, 1920, page 12.
5. Pollution of Water Supplies by Coal Mine Drainage, by C. P. Collins, *Eng. News Rec.*, Vol. 91, p. 638.
6. U. S. Patent No. 1,685,300 (1928).
7. Press Release of W. Va. Geological Survey, 1929.
8. *Engineering and Mining Journal*, 1919.
9. Sealing of Abandoned Mines, by Lietch and Yantz, *Coal Age*, March, 1930.
10. *Economic Geology*, Vol. 2, p. 290, 1907.
11. A Study of the Forms in Which Sulphur Occur in Coal, by Powell and Parr, *Bulletin No. 111*, Illinois Engineering Experiment Station.

AGGLUTININS FOR BRUCELLA ABORTUS IN HUMAN SERUMS IN WEST VIRGINIA

By ROBB SPALDING SPRAY,
Professor of Bacteriology and Hygiene, and

BENJAMIN WINFIELD HESS,
Instructor in Bacteriology.

A report of an agglutinative study of human serums of residents of West Virginia, to determine the existence, and extent of the occurrence of undulant fever.

Of the 2521 specimens tested, 6 showed reaction to a degree suggestive of present or past infection with *Brucella abortus*. In addition 22 others gave reaction to a degree suspicious only. In all 290 specimens reacted positively to some degree, while 2231 were entirely negative.

All of the 6 cases giving strongly positive reactions were traced down, through the report cards, and questionnaires to the attending physicians elicited definite history in only one case. Of the other 5 cases no history of past symptoms of undulant fever could be obtained.

This disease in humans is commonly traced to the use of raw goats' or cows' milk, or to contact with diseased goats, cattle or swine. Figures are presented showing the incidence of the disease in cattle of West Virginia to the extent of at least 25 %.

The disease, undulant fever of humans, shows an increasing prevalence in the United States, and is regarded as a problem of growing importance.

CHEMICAL INDUSTRY DEPENDENT UPON RESEARCH
IN PURE SCIENCE

By C. A. JACOBSON.

Ten years ago or less our laboratories were stocked with Kahlbaum chemicals, Jena glass, Bender and Hobein thermometers, Thuringian porcelain ware, German rubber tubing, German dyes, etc. The excellence of these and numerous other foreign products has been achieved through exhaustive research in pure and applied chemistry supported by industry as well as by the governments. The researches were largely carried out at the universities by graduate students from every civilized country in the world. In many laboratories such as those of Emil Fischer, Abderhalden, Ostwald and others, the foreign students predominated.

It was the unstinted support given to the universities by German industry which enabled them to take the lead over every other nation in chemical production. During the year and a half I spent in European laboratories, prior to the war, ample opportunity was afforded to study the research system in vogue there. Considered as colleague and not as a student seeking a degree, the professors felt free to discuss many subjects with me, that otherwise would have been below their dignity.

The German university student appears to have a greater respect for his professors and the Institution than students in this country. Over there the students feel that their university work is a very serious matter for they know that unless they make good they are immediately dropped. Students come and listen to the professors' lectures and then pass a final examination which tells the whole story whether or not they are fit to go on. There is no temporizing there. The best are picked and given assistantships and then started in early on some dissertation work for the Ph. D. degree.

The professor delivers two, three or four lectures a week leaving the rest of his time free to supervise the researches of graduate students or carry on his own investigations.

This system enables the professor to complete and publish one or more investigations every year so that in a short time he becomes nationally and internationally known, which brings ever increasing numbers of graduate students to his laboratory. After a professor's reputation has thus been established, he will often times have more applications for matriculation in his department than the laboratory accommodates. Such was the case in Emil Fishers', Arrhenius', and Abderhalden's laboratories.

I came away from Europe with the impression that our educational system, meaning by that, the method of imparting instruction, is far in advance of what they have over there, but on the other hand I felt equally convinced that we are almost left out of the running when it comes to scientific research in the universities.

Their system is superior to ours in this respect, that they are able, quickly and effectively, to eliminate the unfit, while we drag them on, year after year, spending huge sums of money and the choicest teaching talent upon these poor or mediocre students, who will never accomplish one creditable thing in the science that they pursue for culture or for pleasure only. Large numbers of these students whose interests are entirely in other fields, or who take chemistry simply to get the required credit, occupy nine-tenths of most professors' time in the smaller State universities, to the exclusion of the few who are majors in the department and would, when properly trained, reflect credit upon the university and the State.

Shortly after I returned to America the World War broke out and we had a vivid picture and an awful object lesson, of the effectiveness of organized chemical research. More than any preceding one, this was the chemists' war, and without doubt would have ended disastrously to the Allied Nations, had it not been for vastly superior natural resources and the ability to quickly mobilize chemical assets in men and material. Chemical units were formed and research started in various places, wherever feasible. The results are well known, but I mention the matter because it emphasizes the importance of

chemical research in a field of endeavor which at that time was more vital than almost any single industry.

Since the war chemical research has been boosted everywhere, but perhaps more in America than in any other country. Most of our universities have established graduate departments, and those who already possessed them have very materially expanded the facilities for graduate study and research. Research departments have also been incorporated into numerous American manufacturing establishments and it is estimated that these industries now spend in the neighborhood of \$200,000,000 annually for investigational purposes. In consequence the new and improved products that are put on the market fully warrant the expenditure of these vast sums. Improved processes have also been developed which cheapen the cost of production.

Some pertinent advice to investors by the editor of one of the largest business journals in the world reads as follows: "Be sure the institution is keenly alive to the importance of scientific research before investing in its securities."

In launching out upon an undertaking of any kind the shrewd business man asks the question: does it pay? What kind of dividends can be declared upon the investment? The same questions are asked when the subject of research is proposed. What evidence can be given that an investment in chemical research will net any returns, now, or in the future? Let history bring forth the answer.

In the eighteenth century Le Blanc received the sum of 100,000 francs from the French Government as a reward for his researches upon common salt, producing the much needed soda ash. Nearly a century later the Solvay Brothers demonstrated that the same results could be obtained by a cheaper and better process, so Le Blanc's was laid aside.

The synthesis of indigo furnishes an interesting chapter in the long list of successes achieved by chemical research. Adolph von Baeyer, professor of organic chemistry at the University of Munich, developed and patented a process for the production of indigo from benzene derivatives, and was

paid over \$100,000 for the same. Baeyer's researches on synthetic indigo extended over a period of ten years, when Heumann took up the work, and developed a new process from a cheaper material, netting him an even greater return. The synthetic indigo industry is now valued in the millions of dollars.

Allow me to recall briefly a few other products and processes that have been evolved from the laborious researches of professors and students in the universities, and that now represent industries valued in the millions of dollars. They are mute witnesses to the importance of chemical research to civilization.

1. Alfred Nobel's work on nitroglycerine and other explosives. His reward was a fortune so large that the interest on a fraction of it pays the five Nobel prizes of approximately \$40,000 every year.

2. Sir William Ramsay's discovery of helium and other rare gasses. The results of his apparently useless research have been capitalized, and the present valuation of this industry mounts up into eight or ten figures.

3. The Curie's discovery of radium and its properties.

4. Remsen's synthesis of saccharine at Johns Hopkins University.

5. Branting's discovery of insulin at McGill University.

6. Haber's discovery of a catalyst that will unite hydrogen and nitrogen to form ammonia. In the Charleston District we have a plant valued at several million dollars based on this process.

7. Charles M. Hall's discovery of an improved method for the production of metallic aluminum, which made the discoverer, and numerous other persons very wealthy, and netted Oberlin College an endowment of over a million dollars.

8. The discovery of the catalyst that made two molecules of hydrogen combine with one of carbon monoxide yielding methanol. This discovery has so cheapened wood alcohol

that in consequence our \$100,000,000 wood distillation industry received its death blow.

9. Sebatier and Senderens, working in pure chemical research, discovered that hydrogen could be introduced into the molecules of unsaturated oils in the presence of finely divided nickel, yielding a saturated, commonly called hydrogenated, oil.

In 1926, 420,000,000 pounds of hydrogenated oils were produced by this process in America, and the production for 1929 has doubtless exceeded 500,000,000 pounds. The world production is about twice this amount. Estimating that the value of hydrogenated oil is eight to ten cents per pound, the hydrogenation industry of the world is worth 80 to 100 million dollars per year. The Procter and Gamble Company are the original developers of the process, as well as the largest producers of this commodity.

10. The electro-chemical industry with its hundreds or thousands of ramifications, has been reared upon some pure research work carried out by Michael Faraday at the Royal Institution in London. Countless metallurgical and refining processes, as well as all sorts of electro-plating and electrotyping processes, have been reared upon the results of Michael Faraday's researches. Who will dare to estimate in billions of dollars the value of this one man's contribution to science and civilization?

This list could be expanded almost indefinitely, and some of you may wonder why I did not mention, monel metal, ore flotation, vitamins, rayon, cracking of petroleum, antitoxins, anesthetics, soil reclamation, improved foods and fertilizers, pyrex glass, rubber, dyes, ceramics, etc. They have all been brought to their present high state of perfection by painstaking and expensive research.

These are the benefits we derive. Are we also contributing our share to the sum total of human knowledge, in order that others may gain some benefit from our labors? Prof. H. N. Holmes asks the question: "Is it right for a great institution of learning to hand out facts other faculties have gathered with-

out sharing in production?" It seems to me, it is very much like the church member who comes regularly every Sunday morning to listen to a well worked out sermon, but never contributes more than a nickle and a smile toward the pastor's salary. Dr. J. McKeen Cattell, President of the American Association for the Advancement of Science, struck the keynote to the philosophy of life when he said words to the effect that the greatest achievement of man is the discovery and recording of new truth, through research, and the production of offspring who will worthily represent us, and continue the advance of civilization in the eras to come.

Humanity has always been divided into two numerically unequal classes: Some lifters, more leaners; a few sowers, many gleaners; a handful of producers, millions of users. The realization of this fact was doubtless the cause of Carlyle losing his temper when he shouted: "Produce, if it be but the pitifullest infinitesimal fraction of a product, in God's name, produce!"

In order to obtain first hand information I mailed the following questionnaire to the Presidents of thirty-four of our largest industries: 1. At what cost in men and money are you maintaining a chemical research department in connection with your industry? 2. Are any of these men employed on pure research not directly connected with the industry? If so, how many? 3. Does your concern provide fellowships or scholarships in chemistry at universities or research institutions? If so, how many, and at what expense? 4. Does your company consider it a good business policy to endow these research fellowships? 5. Could you give any instance or instances where direct monetary returns have been obtained through investment in such research?

In two weeks I had replies from sixteen companies, nearly all of whom gave concrete and definite answers to most of these questions. Every one without exception, maintained chemical research laboratories costing the companies all the way from \$6,000 to \$2,600,000 a year. They all believed in the value of research as applied to their own industry and

nine out of the sixteen considered pure research essential to the extent that they either maintained departments of pure research connected with their own establishments, or supported scholarships or fellowships in pure research in one or more universities. Only one has discontinued such fellowships because as he said, the results appeared not to warrant them.

Of the six who endowed fellowships in universities, four were well satisfied with the returns, while two were not. A few stated that the pure research they supported either at home or in outside institutions did not pay when debits and credits were balanced, but that the benefit derived from the world's output in pure research was so great, that they considered it their duty to society to continue this expense, in order to share in the production of truth, and to contribute to the fund of common knowledge.

The function of a real university is two fold. First, to impart knowledge; Second; to create new knowledge. The one should go in lock step with the other. We the citizens of West Virginia would have scarcely no opportunity to do our share in advancing the boundaries of science and civilization unless it could be done through our representative, the State University. That is the only logical place in the State where research can be prosecuted to good advantage. But is the University producing as it should? If not, why not?

Before any comparisons with other States are made it must be remembered that mining and selling coal is the principle industry in West Virginia; and that the manufacturing industries, outside of glass and salt, are comparatively recent institutions. It is also within the last few years that the University has given its instructional personnel any time for scholarly production. For these reasons we need not be surprised that our rank as producers of new chemical knowledge is much lower than we should like to see it.

The Journal of the American Chemical Society, The Journal of Industrial and Engineering Chemistry, and the Journal of Physical Chemistry are leading repositories for articles recording the results of chemical research in the United States.

All such articles representing American production, appearing in the 1927 and 1928 volumes of the above journals, were counted and listed by States as follows:

1. New York	288	27. Louisiana	6
2. District of Columbia	163	28. Vermont	6
3. Massachusetts	156	29. Kansas	5
4. California	154	30. Oklahoma	5
5. Illinois	151	31. Utah	5
6. Pennsylvania	141	32. Wyoming	5
7. Ohio	92	33. Georgia	4
8. Wisconsin	81	34. West Virginia	4
9. New Jersey	80	35. Arizona	3
10. Michigan	68	36. Idaho	3
11. Maryland	54	37. North Dakota	3
12. Minnesota	54	38. Alabama	2
13. Iowa	48	39. Florida	2
14. Indiana	31	40. Maine	2
15. Connecticut	30	41. Nevada	2
16. Missouri	23	42. New Hampshire	2
17. Texas	14	43. Tennessee	2
18. Washington	14	44. Mississippi	1
19. Virginia	13	45. Montana	1
20. North Carolina	12	46. South Dakota	1
21. Colorado	11	47. Arkansas	0
22. Kentucky	10	48. New Mexico	0
23. Oregon	9	49. South Carolina	0
24. Nebraska	8		
25. Delaware	7		
26. Rhode Island	7		
		Total	1783

The total production for the two years recorded in these journals was 1783 articles of which West Virginia supplied four or a little more than .2%. A slightly consoling aspect of the matter is the fact that our position is not much more than two-thirds of the way down the list. There are fifteen states showing a poorer research record than we do.

While the table just given is interesting, it would be even more so if we were to get the names of the men who did this work listed by native States, for we have a long list of able chemists who have gone from West Virginia and are now doing high class research work elsewhere.

However, the evidence is conclusive that the chemical productivity in the northern states completely overshadows that in the southern. Nevertheless the south has both wealth and brains; and the big problem is to coordinate and direct the two into proper channels, which, when accomplished would yield results, of which no man ever dreamed.

Another interesting method of geographically allocating chemical productivity would be to list the world's notable achievements in the field for 1928, as summarized by Science Service of Washington. Such a list was prepared, and wherever possible the achievements credited to the country and State where the work was done.

District of Columbia.....	6	Massachusetts	1
Germany	6	Michigan	1
New York	5	New Jersey	1
California	3	Pennsylvania	1
Illinois	2	Switzerland	1
Canada	1	West Virginia	1
Iowa	1	The Other 39 States.....	0

Of the thirty notable credits allotted to the world West Virginia receives one, and of the six given to Germany one constitutes the Nobel Prize award for that year. So few credits come our way that it seems within the bounds of propriety to point them out when they do come.

The Chemistry Department of our University is at present primarily equipped for teaching, and for that reason it has been necessary for those of us who have had a little time and inclination to carry on some investigations, to fit our problems to the equipment, rather than the equipment to the problems. There are several members of our staff who are well trained, willing and eager to carry out research if they had the opportunity. The urgent need right now is for the completion of the chemistry building, and the purchase of about \$25,000. worth of research equipmnt. Besides this we should have an endowment for ten or a dozen fellowships, in order to induce promising men and women students to remain and pursue graduate work here, instead of going elsewhere.

At the dedication of the chair of chemical education at Johns Hopkins University, President Ames announced that \$40,000. had been contributed to the University by the Rockefeller Foundation for special laboratory equipment in connection with the industrial fellowship plan they have recently put into operation there.

Success in research is not only dependent upon previous training, familiarity with elaborate equipment and methods, and the ability to readily interpret chemical literature in our own and foreign languages; but also upon having the proper attitude toward life, humility, patience, and perseverance through apparently insurmountable obstacles. These are the qualifications that mark the successful research worker. But given a man with the above mentioned qualifications, successful research production is conditioned even more by factors, entirely beyond his control. He must have a fairly comfortable and convenient laboratory in which to work. He must be as free as possible to exercise his own ingenuity in the attack and prosecution of his problems. He must be made to feel that his work is appreciated and that his needs are met as expeditiously as possible. We, in the Chemistry Department of the West Virginia University, are fortunate in having a splendid esprit de corps. No ostensible friction between the members. Most of us realize that encouragement is the key that unlocks the door to an unsuspected reservoir of power for the advancement of research.

MENTAL HYGIENE AND YOUTH

By R. M. CHAPMAN.

Mental hygiene concerns itself with the preservation of good mental health and the prevention of mental disease. We may for our purpose, it seems to me, define good mental health or normal mental health as being good or normal in proportion to the capacity of the individual to meet successfully the problems that life brings him. This it is at once recognized is a very broad definition. The variety of problems that we all have to meet covers a wide range. It includes all sorts of things from the little ordinary adjustments that we have to make in contact with our friends or enemies in the course of the day and our conforming more or less happily to the conventions, moral code and laws of our time to such disasters as business failures, the loss of relatives and physical illness.

The variety then of the problems which we all of us have to meet, as I have said, is broad and the scope of interest of the physician or others who concern themselves with mental hygiene must be equally broad. The mental hygienist is interested in human behavior. There is nothing more interesting to my mind than why we humans behave as we do. He is moreover interested in human behavior in all the different difficult situations that arise to confront us.

In such a presentation as this, however, one must be exceedingly careful or he will lose himself in the great range of human individual problems and behavior reactions. It would seem then at first it would be best to select a somewhat well defined road down which we may walk for a period looking at the development of the mental hygiene movement from the point of view of its initial relationship to more obviously medical problems and then (after a rather free use of illustrations) approach as best we can in the time at our disposal the wider implications of our subject.

The formal mental hygiene movement originated in the published experience of one man, Clifford Beers, who a little over twenty years ago wrote "The Mind That Found Itself."

Mr. Beers who suffered from a serious mental illness described his experiences in certain mental hospitals with a clarity and appeal that made a great impression on all who read it. He was one of that very considerable number of people who recover from mental illness to make good use of the experience they have gained. His presentation was properly critical but put forth without rancor. Without going further into detail the interest roused by his book was so great that influential men and women, physicians and laymen, came together and formed the National Committee for Mental Hygiene, which is functioning today. The first state mental hygiene society was formed in Connecticut just previous to the formation of the National Committee. Since that time such state mental hygiene societies have been formed in many of our commonwealths and in a host of cities and counties. The chief aims of the Committee in the beginning were three in number:

1. The improvement of the care given the insane actually in hospitals.
2. The passage of state legislation that would make for a definite improvement in the methods of handling the insane in the various states.
3. General education of the public at large as to mental disease, its significance in the community and family and what might be done in the way of prevention and amelioration of the conditions under which it arises.

Financed by individuals and foundations the National Committee has done a great work for these past twenty years. Nation wide interest has been stimulated. Most of the states of our union have asked the Committee for surveys, for a study of their problems in the care of the mentally diseased and the springing up of numerous societies, small and large, has reflected a continuing interest on the part of thinking people everywhere. Societies based on the same principles have been formed in foreign countries and next spring there will be held in Washington the first international mental hygiene conference to which some thirty or more countries will send delegates.

The growth of the mental hygiene movement would, however, have progressed to no such lengths if it had not been for certain other stimulating studies of far reaching importance. Better and more thorough work was being done in the public mental hospitals of the country, particularly in two states—New York and Massachusetts. The behavior of patients was being studied from new points of view. Their histories were being more carefully gone into. The relationships between the problems of individuals and their behavior reactions were being more carefully scrutinized by the physicians who were caring for them. As time went on and the life histories of mentally sick people were worked out in more detail certain findings of interest and importance began to emerge and among them the most important, the most striking, was the significance of personality development from birth on in the life of every individual in its relationship to success or failure in later years.

May I become at this point more sharply defined and rather more medical in my approach? The individuals under study at the hands of these physicians a decade and a half ago were mental patients suffering from neuroses, psychoneuroses, and the more serious psychoses or insanities. They were found in state hospitals, in private institutions and in private practice. The difference between them were largely of degree of depth of reaction. I suppose I should digress to say a word at this point on the causation of mental disease in general. Very generally, we may first speak of heredity so far as its influence on the development of mental disease as being something that we do not know after all very much about. It is to my mind inconceivable that we can know much about it until the human being lends himself to experimentation as do the lower animals and plants. That there are inherited constitutional characters which may play their part in the production of mental disease seems possible but it does not seem to me we can say much about it. We do know that heredity may play a definite role in feeble mindedness. Second, there are many and varied organic causes of mental illness—senility, arteriosclerosis,



sypilis, the acute infections, the endocrinopathies, traumatisms, etc. Acknowledging this, we must pass on. The chief subject of this discourse is the vast mass of mental illness, disabilities of varying degrees and kinds which are termed functional. I believe that the biological chemist, that the pathologist, the endocrinologist, and the clinician working in close contact with the laboratory may find other organic factors than we know of today, which will contribute to our knowledge of the causes which produce mental disease. All of us hope that such discoveries will be made but the fact remains that today for the greatest number of those suffering from mental illness we know of no consistent pathology, no organic basis.

One thing which had been noted from the more careful study of mentally sick people was the fact that some event seemed to precipitate the illness. Such events are loss of money, loss of relatives, such major social events as engagements, marriage, social disasters of one sort or another, humiliations; but these evident enough precipitating causes—the straws, so to speak, which seem to break the camel's back—did not seem sufficient. All of us have to meet such stresses and most of us seem to muddle through fairly well, but why was it that some broke in the face of a stress normal to life and others withstood such stresses successfully? Besides many serious mental illnesses occurred without evident reason.

May I present briefly a few cases—The first is that of a young woman of twenty years, daughter of wealthy and cultured parents who had given her every advantage. She was over six feet in height and awkward. Defective vision made it necessary for her to wear very thick lenses. Her nose was large. Her mouth was coarse. She was most ugly. She came to the hospital suffering from a serious excitement in which there were symptoms that seemed to point toward a bad outlook but nevertheless she improved considerably and was finally able to go home and did well for sometime. Since then she has had another period of hospital residence. Her future is most uncertain.

A careful study of the development of her personality

revealed the following facts: As is the case with ugly ducklings, she was the favored child of her mother. From early childhood she was especially protected. She had her own maid as she grew older but before that she was guarded and guided by nurses, governesses and tutors. Intellectually keen she developed quite a little literary ability. She traveled widely but had few close associates of her own age. She never bought her own railroad tickets. She never packed her own trunk. She never knew what it was to be responsible for the little personal demands that every growing girl and young woman has to meet in the way of looking after herself. She was almost unbelievably protected from the demands of real life. And so it went until at the age of nineteen she suddenly decided that she would like to go to college and chose a large State University. Her mother agreed with her wishes and for the first time she stepped out alone into the complicated social and scholastic demands of a great university situated in a great city. She was immediately made conscious of her own helplessness, a thing that she had not realized before. She had the greatest difficulty in fitting in to the ordinary relationships which to the average young woman would not have been difficult. She felt bruised and baffled, inadequate, inferior and her mental illness followed logically enough after only a few weeks of the effort to adjust herself to the environment for which she was not fitted.

The second case is that of a young man of twenty-one who came to the hospital suffering from a serious mental disorder which had lasted, however, only a few weeks. He showed unmistakable symptoms that pointed toward a definitely bad prognosis. He was after a few months transferred to the state hospital and he will remain there the rest of his life as a charge on the state.

A study of the development of his personality revealed that he was the youngest child of a family of eight children those older than himself all being girls. He was spoiled from infancy. He learned as an infant that if he made noise enough he could get anything in his environment practically that he

wanted. As he grew older (he was intellectually normal) he learned many ingenious ways other than crying to get what he wanted. As an adolescent he drove two or three of his older sisters out of the home on account of his behavior. He was the ruler of the household, a spoiled child of the most disagreeable type. Unfortunately, on account of his going to school in the same town he remained in the family until he was twenty. He managed somehow to avoid trouble during his preparatory school and college days but it must have been solely through his ability to secure protection at home. At twenty, however, he was offered a job as a bond salesman in New York and left home for the first time to undertake this work. His break down occurred within three or four months after leaving home.

Here was a boy utterly spoiled, who had no conception of the give and take of life, of how to lose gracefully. He was quite incompetent to enter into any sort of competitive existence. He had always had his own way. He had been singularly dependent on others. His personality was badly balanced and when he came to meet life as it has to be lived he could not possibly adapt himself. Such an individual is at a great disadvantage when he comes to meet the responsibilities of adulthood.

The third case is that of a young woman, who came under observation at the age of twenty-three. She was suffering from a mental illness from which after several months she recovered.

On admission and for some weeks thereafter her chance for recovery seemed doubtful. She was absorbed, out of touch with her surroundings and suffered from very active hallucinations. Superficially there seemed to be no adequate reason for her breakdown, save that it came a few weeks after her becoming engaged to be married. A more careful study of her developmental years as a child and during her teens disclosed that she very early showed a timidity, self-consciousness or shyness so far as boys were concerned. She never played with them naturally and she developed—so far as her relations to the opposite sex were concerned—a sensitiveness that was marked. She was extremely prudish. She was popu-

lar with girls of her age, was intelligent and developed—after business training—into an excellent secretary. She met a highly eligible young man who swept her off her feet in a whirlwind courtship and she found herself engaged within a few weeks, apparently, scarcely appreciating what she was doing. Her mental illness in the light of the details we know originated in the fact that she was unable to adapt herself to the engagement situation and to the contemplation of marriage.

In this instance we have a girl the social side of whose personality was not normally developed. It was, on the other hand, badly balanced. Her sociosexual outlook on life was not frank. It remained infantile and confronted with the necessity of making one of the major adaptations in life she failed.

These three cases illustrate the results that careful and painstaking studies of thousands of cases of major mental disaster discloses—namely, that in almost every case where detailed information as to the developmental years was available peculiarities of personality existed prior to the obvious mental break. It may be said to have been demonstrated beyond any shadow of doubt that the greatest factor of causation in the functional mental diseases lies in abnormal personality development, that the soil in which mental disease flourishes is prepared during the years of childhood, adolescence and youth, that the so-called problem child or peculiar child—spoiled, shy and seclusive, incorrigible, cruel, emotionally unstable, precocious in various ways, delinquent or defective—is potentially the social outcast, the criminal, the inefficient, the neurotic or the insane individual of adult years. Attention, naturally, then was focused on the mental health of children and young people. Careful surveys made in various communities disclosed the fact that some six percent of children in our common schools were either defective or peculiar in some way while being of normal intellectual capacity.

The number of mentally sick in public and private hospitals in this country is approximately equal to the number of physically sick people occupying beds in the general hospitals.

The number of individuals more or less mentally crippled in the community but cared for at home or limping along as best they can in various walks of life is very large indeed. If we add to this number, who in the usual medical sense are to be considered as mentally affected, the great number of social offenders, who have demonstrated their ability to adapt themselves to the demands of the law, we have an army of dependents on the states the cost of which in money is incalculable to say nothing of the suffering caused families and individuals.

If it has been proven, as it has, that this army originates or comes largely from the ranks of the peculiar and defective children of the community, it is natural enough that children and young people be made the point of attack—all the more so because the child studies during the last ten years indicate unmistakably that where co-operation from relatives may be secured much can be done to correct peculiarities, defects in development and the traits that allowed to set—become ingrained—make for disaster in adulthood. Such young people are at a disadvantage when they come to meet the responsibilities of adult years. It is at that time that the break usually comes.

And so mental hygiene having as its main object the prevention of mental disease has found something definite, tangible, visible, upon which to work. During the last decade special attention has been paid to children. The child guidance movement has made great progress. It has become recognized that the peculiarities of children, their varyings from the normal, arise as a result of environmental forces. In a very large number of cases, indeed, parents are unwittingly the cause of the development of childhood peculiarities. Many of these peculiar traits in children, as I have said before, respond immediately to ordinary common sense treatment.

Some two years ago I was asked to see the eleven year old son of a clergyman. I was told that the boy had quite suddenly become unmanageable, profane, obscene, independent in his behavior, insisted on going out at night, running away from home and was cruel to his younger brother. Before I saw the

boy I talked to his father and mother. I found them a sensitive, stiff couple, very active in their religious observances in the home, demanding much of their children, rigid, detached, not close to their children. The father admitted that he did not play with his young son or understand him at all. The method of handling the boy was by commands. Penalties were either whipping or an extra heavy dose of Bible reading and prayer. Illustrative of the method of handling this child the father and boy were on a street car sitting toward the rear. A lady entered and the father curtly commanded the youngster to get up and give the lady his seat. The boy equally curtly said that he would not, whereupon the father took him by the collar and marched him to the other end of the car. Such humiliating experiences had become rather common. Neither the father nor mother had any idea as to what was wrong but felt very deeply that something must be done. The youngster was a somewhat appealing eleven year old, a little under size, very bright—reading books in advance of his age and leading all other children of his years in school. He was naturally suspicious, hard to get at, rather bewildered as he might well be by his troubles at home, feeling that there was injustice somewhere but not able to put his finger just where the trouble was. I did not spend much time with him. It was useless to try to do anything for him in the home atmosphere. What was wrong with this boy was really very simple. The family had just returned from a foreign country where the father had been a missionary for some five years. In their absence abroad this boy had had little opportunity to play with children of his age or with other white children of any age. His mother who was a good teacher had stimulated his intellectual interests. His energies had been developed particularly along that line and he came to Baltimore and to one of the private schools of this city to be placed with a class of boys from three to four years older than he. From the point of view of class work he was properly placed. In every other way he was not. There is a considerable difference between the average eleven year old and the average fourteen or fifteen

year old from the point of view of general interests, physical development, etc. He was too immature to enjoy the physical exercises and games of his classmates. Always under parental restraint, he found himself with a group of boys who were going to the movies alone and enjoying a degree of social liberty of which he had never had any conception. As he heard language that was new to him and had his attention directed along interesting and curious lines that he was not prepared for. His classmates were very busily engaged in establishing their independence of their families as rapidly as possible and he faithfully followed in their footsteps. Naturally imitative, cuffed about more or less by the boys of his class and with the necessity of making himself feel superior to someone, he took it out on his little brother. We do not need to go further into detail. With nothing done for this boy it would be hard to say just what the result might have been. What he needed was a kindly and understanding older person in whom he could have confidence and who could steer him. He needed nothing but intelligent handling by both parents and teachers. In this instance it was impossible to do anything with the parents and he was removed to a private school at a distance where he would not be in contact with his home and where the head master was known to be the sort of man who could handle such a boy intelligently. I am informed that he has done well since. It is of such situations that the neurotic, psychotic and criminal tendencies are born.

We have then the stiff, ruthless and righteous parent who arbitrarily inflicts on the child his conception of the difference between right and wrong—a difficult task when applied to the intimate problems of a clear headed, normally curious adolescent who wants to know *why* such and such a thing is wrong.

No less destructive is the *over-solicitous*, gentle parent (usually the mother) who controls just as effectively the development of the child's personality—and there are others. But these I have mentioned are the worst of all for they fail at the crucial period of parenthood to encourage in the child the

development of those qualities of independence and self reliance so necessary to the adult.

The boy or girl is fortunate who comes to the age of puberty with its problems to find a wise older person to whom he may talk—with whom he wants to talk. To illustrate, the dictum that masturbation is a Sin which indulged leads to disease, insanity, etc., besides being untrue has provoked in many a youngster an attitude of suspicion toward his own sexual organs, a feeling of inferiority which has affected him adversely thereafter.

It would not be fair to tell of the development of the mental hygiene movement without giving due credit to the stimulus of Sigmund Freud and the influence he has exerted on the psychiatric studies and treatment of the last twenty years. His earlier theories of the origin of all functional mental troubles in sexual conflict have been modified by him and further modified by former disciples of his. I wish merely to say in passing that the tools he has given the psychiatrist to work with have been and are proving to be of inestimable value in disclosing the nature of mental mechanisms and more particularly in disclosing to us the unconscious motivations for human behavior. Psychoanalysis wisely used by the competent physician has proven an instrument of great value both in therapy and research.

The focusing of attention on the child and the adolescent has created a great stir. Because it is on his first contact with school that the child's peculiarities are apt to become recognized it was natural that the interest of teachers should be engaged. The interest of educators has been demonstrated through the forming of special classes for defectives where they may be taught up to their capacity and not forced to undertake more than they can do. It is in confronting these defective children with unfair competition that trouble originates. The intelligent child—but peculiar—is now getting the individual study he needs occasionally at the hands of special teachers, social workers on public and school playgrounds and at the hands of psychiatrists in the schools. Educators gener-

ally are recognizing that their responsibilities do not end with the introduction of as much book learning as the young mind may absorb but that there is a further definite responsibility for him as an individual who must get on with his fellows. A very considerable number of universities have brought into their staffs psychiatrists who are available for the advising of young men and women whose emotional problems are such as to interfere more or less with their scholastic and social progress. At a dinner of the National Committee for Mental Hygiene in New York recently President Angell of Yale expressed clearly his conviction as to the great value of the Mental Hygiene department to the university. Inaugurated and conducted wisely and matter-of-factly with nothing formidable about it, it has served three main ends.

1. The elimination from the student population of an occasional destructive psychopathic student who could not be reached or benefitted.

2. It has given to the student whose scholarship or social behavior was suffering an opportunity to discuss intelligently his causal emotional problems usually to his great relief.

3. It has elevated the morale of the university through its influence in interpreting faculty to student and student to faculty.

The individual youth is at last beginning to receive the attention that is due him and the help that many must have if they are to arrive at years of maturity well-balanced and as fully equipped as may be to meet the stresses of life.

Intelligent parents, naturally, have responded eagerly. The result has been the formation of parent-teachers' societies throughout the country. The range of interest of the social worker has broadened and her responsibilities have increased. The field of psychology and its interests have widened. The development of mental hygiene clinics for the benefit of our communities is most striking. In many of our states the state hospitals have established in the areas they serve clinics visited by members of their staffs to which people may come with their problems whether they be children or adults. Some of

our great foundations have interested themselves in the establishment of fellowships for promising young men and women physicians who after sufficient training may go out to various communities in the country to work with clinics supported by the same foundations. The plan has been followed by some foundations of financing a clinic in a community over a period of five years during which support is gradually withdrawn in the hope that the community will undertake and carry on the work. These clinics not only work directly with children and adults but do educational work particularly with social workers for the various welfare agencies in the community so that they may carry on intelligent common sense treatment of some of the problems of the families with which they come in contact.

What is actually done in clinics for the problem child and the delinquent? We may recognize at once, naturally, that the amount of work to be done—clinical, educational and informative—is far beyond the possibility of accomplishment by any single group or profession. The psychiatrist too often deals with the end results. He rarely sees a case until well nigh irretrievable damage has been done. Preventive work in general must be done under his guidance, but to a very considerable extent it has to be done by others. I have just attended a second discussion between a group of psychiatrists appointed for the purpose and representatives of the social sciences almost all representing various universities. There were professors and representatives of departments of sociology, social psychology, anthropology, political economy, ethnology, religious education, criminology, penology, law, education. They had come together now the second year—the meeting financed by one of the foundations—with the end in view of seeing if some common ground could not be found for contributions to the study of the influences that operate on the development of personality of the individual. It is reasonable to suppose that much can be contributed by the various social sciences.

It is interesting to note that various of our theological sem-

inaries, schools for priests, are asking psychiatrists to talk to their students regarding the varied causes of emotional conflict of individuals. As a psychiatrist I see as often as any other sharply defined etiological factor in the mental break downs of youth the puzzling of the individual over questions of what is right and what is wrong. So far I have not been able to discover any one who is so wise as to be always able to define just what is right and what is wrong for the individual boy or girl.

The greatest problem the mental hygiene movement has to contend with is its lack of trained personnel. The medical profession itself has been slow to recognize its responsibilities. There is as yet no well developed sense of mental disease as a public health problem. Suicides read by the physician in the paper every day with the usual context do not begin to arouse in him the feeling of disquiet that would be his if his attention were called to a death from typhoid fever or small pox. And yet six percent of the school children in our common schools—accessible to our health departments are marching on their way to disaster of one sort or another.

Psychiatry is still inadequately dealt with in our medical colleges. It is not very often that it is placed before the student in an attractive light. And yet no field of medicine offers more attractive clinical or research problems. Blunders have been made. Impossible claims have been advanced. Some enthusiasts have felt that the mental hygiene movement with all that it implies is bringing about the millennium. Nothing could be further from the truth. We do believe that forces have been discovered and are being gradually more intelligently directed which through future generations will accomplish much to give to our boys and girls a better chance for reasonably happy and successful lives.

ABSTRACTS OF PUBLISHED ARTICLES

DEPARTMENT OF AGRONOMY AND GENETICS

1. **Watering Potted Soil Kept under Microbiologically Controlled Conditions**, by E. P. Deatruck. *Science*, Vol. 68: p. 114-115. Aug. 1928.

When soil in large pots is to be used, some method must be found to cover the soil with a cotton seal which will not be wetted by the moist soil. This can be accomplished by placing an inch mulch of very coarse gravel over the soil.

2. **Reduction of Soil Nitrates During the Growth of Soybeans**, by E. P. Deatruck. *Jour. Am. Soc. Agron.* Vol. 20: p. 947-958. Sept. 1928.

In following soybeans with winter wheat it is advisable to plant soybeans of shorter growing period so as to allow for longer intervals for nitrification in the soil before the planting of wheat. Nitrates in soils under maturing soybeans are very low.

3. **Determination of the Fineness of Marl**, by E. P. Deatruck and Clarence Dorman. *Soil Science*, Vol. 27. p. 121-122. Feb. 1929.

Determinations made according to the standard method—that of calculating the percentages of material of certain finenesses from the weights of thoroughly dried material held on the screens after thorough shaking—are inaccurate.

4. **The Relation of Smut Infection to Yield in Maize**, by R. J. Garber and M. M. Hoover. *Jour. Am. Soc. Agron.* Vol. 20: p. 735-746. July 1928.

Selfed lines of maize may be isolated which differ sharply with respect to the resistance to smut. Corn plants infected with smut in the tassel only, yielded on the average more than did plants of similar genetic constitution but free from smut.

5. **Breeding for Disease Resistance with Particular Reference to Smut of Oats**, by R. J. Garber, N. J. Giddings, and M. M. Hoover. *Scientific Agriculture* Vol. 9: p. 103-115. Oct. 1928.

Breeding plants for resistance to disease offers one of the most satisfactory means of controlling numerous plant diseases.

6. **The Nature and Significance of Mutations in Present-Day Breeding Methods**, by R. J. Garber. *Scientific Agriculture*, Vol. 9: p. 133-143. Nov. 1928.

Among field crops mutations of economic value appear so rarely that one would hardly be justified in basing a system of breeding upon their chance occurrence.

7. **Natural Crossing between Plants of Hybrid Origin in Oats**, by R. J.

Garber and M. M. Hoover. Jour. Agr. Res. Vol. 38: p. 647-648. June 1929.

Among 15 black-seeded plants growing among forms supposed to be homozygous for white seed, 14 segregated for seed color in the next generation, showed conclusively their hybrid origin. One of the plants bred true for black seed, and therefore it probably was the only one of this group whose presence was due to an accidental mixture.

8. **Transgressive Segregation for Susceptibility to Smut in an Oat Cross**, by R. J. Garber, N. J. Giddings, M. M. Hoover. Jour. Agr. Res. Vol. 39: p. 953-962. Dec. 1929.

Gopher, moderately susceptible, was crossed with a highly resistant if not immune Black Mesdag. Resistance to smut is apparently dominant and controlled by a single main factor difference. There is apparently a linkage between the black-colored gene and a modifying factor which brings about transgressive segregation for susceptibility.

9. **Wheat-Rye Hybrids**, by M. M. Hoover. (Note) Jour. Heredity Vol. 20: p. 171, No. 4. April 1929.

Fultz 7 wheat was the seed parent, and Rosen rye No. 3 the pollen parent. The hybrid plants resembled wheat rather closely, although they were intermediate in most plant characters.

10. **Tests of Native and Foreign Clover Strains in West Virginia**, by T. E. Odland and R. J. Garber. Jour. Am. Soc. Agron. Vol. 21: p. 355-360. March 1929.

Clover strains of Italian origin were worthless for West Virginia conditions, and from other European countries and Chile, generally undependable. Uniformly good results were obtained with strains from Ohio, Wisconsin, Michigan, Idaho, and Tennessee.

DEPARTMENT OF ANIMAL HUSBANDRY

1. **Growth Studies With Swine**, by J. H. Longwell, H. O. Henderson, and W. M. Insko, Jr. Bull. 230 W. Va. Agr. Exp. Station. 24 p. Mar. 1930.

DEPARTMENT OF BACTERIOLOGY

1. **A Useful Medium for Cultivation of the Gonococcus and Allied Organisms**, by Robb Spalding Spray. Jour. Lab. and Clin. Med. Vol. 15, p. 179, (1930).

Presentation of a new medium based on the principle of filtration of meat infusion through glass wool to prevent adsorption of some "growth-accessory factor," which is essential to the successful cultivation of the more strictly parasitic organisms. To this medium are added certain other substances, including nutrose and starch, which further increase the suitability of the medium for its designed purpose.

The medium is now prepared commercially in dehydrated form by the Digestive Ferments Company of Detroit, and is available to the small laboratory which has not the facilities for collecting and handling sterile blood or serum, which substances are usually required for cultivation of these organisms.

2. **Lead Acetate Agar (Dehydrated) for Differentiation of the Typhoid-Paratyphoid Bacteria**, by Robb Spalding Spray. (Note) Manual of Dehydrated Culture Media; Digestive Ferments Co., Detroit, Mich.; 2nd Ed., p. 101 (1929).

A modification of the original formula of Jordan and Victorson. This medium gives excellent differentiation of the hydrogen sulfide forming bacteria from those which do not split proteins to this end product, at least in detectable amounts. It has a further advantage in that this new formula entirely lacks any inhibitory activity, permitting luxuriant growth and an active proteolytic action.

Dysentery bacilli, which are strongly inhibited by the concentration of the lead acetate of the old formula, show no trace of inhibition in this new medium, and can be clearly differentiated from the closely related typhoid bacillus.

The medium is obtained in the dehydrated form, and is prepared from the powder by dissolving in water and sterilizing. The sterile medium is complete in itself, and requires no titrating nor adjusting of reaction.

3. **Kligler Lead Acetate Agar (Dehydrated) for the Differentiation of the Typhoid-Paratyphoid Bacteria**, by Robb Spalding Spray. Manual of Dehydrated Culture Media; Digestive Ferments Co., Detroit, Mich., 2nd Ed., p. 103 (1929).

A modification of the original formula of Kligler, in which lead acetate is combined with Russell's double sugar agar to give an initial grouping of all of the members of the Colon-Typhoid-Paratyphoid-Dysentery group.

Like the plain Lead Acetate Agar, this formula shows a sharp reaction of hydrogen sulfide, combined with the varying fermentative reactions of dextrose and lactose. Having no inhibitory action it affords luxuriant growth, and gives a more complete initial identification of practically all members of the group.

It is also prepared from the dehydrated powder, is readily available, and is easily and quickly prepared.

DEPARTMENT OF BOTANY

1. **Plant Ecology of Spruce Mountain West Virginia**, by Earl L. Core. Ecology, Vol. 10, p. 1-13 (1929).

Spruce Mountain, the highest in West Virginia, (4860 ft.) extends

upward from the Carolinian life zone at its base through the Alleghenian (or transition) to the Canadian zone at the summit. A heavy beech-maple forest forms the natural vegetation at the foot of the mountain. Higher up this merges into oak-hickory and, near the summit, into the spruce-birch forests typical of the Canadian zone. The greater portion of the original forests have been destroyed by fires and cuttings. On the summit the return to the climax association is very slow due to exposure and rigor of the climate. The bare ground is first reoccupied by a fern, *Dicksonia punctilobula*, followed by various species of heath, *Crataegus*, and finally by spruce.

DEPARTMENT OF CHEMICAL ENGINEERING

1. **Progress in the Treatment of Paper Mill and Tannery Wastes**, by W. W. Hodge. Selected Papers from Proceedings of the Fourth Annual West Virginia Conference on Water Purification. W. Va. Univ. Eng'g. Expt. Station, Tech. Bul. No. 2, p. 47-62 (1928).

The cooperative research on control of stream pollution in several states is reviewed with special reference to the methods developed for treatment of pulp and paper mill and tannery wastes. Flow sheets are given showing the processes used by two large plants in treating their wastes. Some valuable by-products are recovered and the process waters are returned to the streams in nearly as pure a condition as when taken from the rivers for use in the manufacturing processes. Recovery and treatment units recently in certain West Virginia paper mills and tanneries are described and the importance of cooperative research to develop methods for reducing stream pollution in this State is discussed.

2. **Tastes and Odors in Water Supplies with Special Reference to Waste Liquors from By-Product Coke Plants**, by W. W. Hodge. Bull. W. Va. Univ. Sci. Assoc. Vol. 2, No. 3, p. 30-45 (1928).

The custom of ancient cities of securing their water supplies from pure sources even though far distant is contrasted with the modern plan of applying chemicals and filtration to purify polluted water obtained from nearby sources. Seven classes of substances causing offensive tastes or odors in water supplies are enumerated, water works troubles caused by these different substances and the usual remedies for each are outlined. Data obtained from experiments made in an investigation whereby the bad tastes in Morgantown's water supply were found to be caused principally by waste liquors from by-product coke ovens emptied into the Monongahela River some 20 miles upstream are tabulated and discussed. Different methods for treating phenolic waste liquors are described including the one installed by the coke company, which is now profitably recovering 95% of the offending phenols from

the waste liquors. Through cooperation between the coke company and the University Department of Chemical Engineering and the State Department of Health a bad case of stream pollution has been largely eliminated and Morgantown now very seldom has bad, tasting water.

3. **Chemical Engineering as a Profession**, by W. W. Hodge, W. Va. Univ. School of the Air. College of Eng'g., Radio Talk No. 8, W. Va. Univ. College of Eng'g. Extension Bull. No. 8, p. 59-65 (1929).

The stupendous growth of manufacturing industries in the U. S. A is outlined. Values added to raw materials by manufacturers was in 1869 about $1\frac{1}{3}$ and in 1927 some 27 billions of dollars, nearly one-half of which was produced by chemical engineering industries. Brief discussions are given of the application of the unit operations of chemical engineering to a few typical process industries, such as the manufacture of chemicals; foods and other home necessities; automobiles; textiles; rayon, viscose and dyes; iron and steel, non-ferrous metals and alloys; lime and cement; pulp and paper; electrochemical products; coal gas, coke and coal tar by-products; and the refining of petroleum. The rapid increase in enrollment and facilities available in the Department of Chemical Engineering at W. Va. Univ. is described together with the curriculum of the course. The great importance of thorough training in the fundamentals of mathematics, mechanics, chemistry, physics and engineering is emphasized and the qualifications for, and usual duties of a chemical engineer are outlined. The names of a few noted chemical and metallurgical engineers are mentioned and attention is called to the favorable opportunities open to young chemical engineers in industries which are developing the abundant raw materials available in West Virginia.

4. **Treatment of Trade Wastes a Necessary Feature of Stream Pollution Control**, by W. W. Hodge. Selected papers from Proceedings of the Fifth Annual W. Va. Conference on Water Purification. W. Va. Univ. Eng'g. Experiment Station, Technical Bull. No. 3, p. 75-83, (1930).

A statistical review for the U. S. and for W. Va. shows the great recent growth of manufacturing with a concomitant production of vast quantities of trade wastes. An ever increasing population requires greater quantities of pure water, hence scientific treatment of trade wastes becomes imperative for the public welfare. The objective for investigations on treatments of the waste materials should be to recover or produce from them useful by-products. Some of the recently developed processes for treatment of wastes from by-product coke and coal gas plants; pulp and paper and lumber mills; and from oil refineries are outlined. The progress made along these lines in Wis., Minn., Mass.,

and W. Va., the advantages of sanitary stream surveys; of establishing definite sanitary districts in the State and of constructing properly designed plants for treating the sewage and industrial wastes produced in each district are discussed. A plea is made for vigorous cooperative support for the research work started by the recently created State Water Commission. A bibliography follows the article.

5. **Possible Future Uses of Clays**, by W. A. Koehler. Jour. Amer. Ceram. Soc., Vol. 11, p. 107-9 (1928).

The need for investigation of new uses for clays which may become necessary if new materials are substituted for brick is stressed. The shortcomings of brick, and possible new methods of clay processing are enumerated. (Quoted from Ceramic Abstracts, Vol. 7, p. 192 (1928)).

6. **Mullite Refractories Extend Field of High Temperature Processes**, by W. A. Koehler. Chem. Met. Eng., Vol. 35, p. 86-88 (1928).

A discussion of mullite and its formation from sillimanite, cyanite, and andalusite, all of which decompose spontaneously into mullite when heated. Cyanite and andalusite expand during this conversion to such an extent that it is necessary to calcine them before making them into shapes. In making shapes, the mullite is usually bonded with plastic kaolin, although some manufacturers are making brick without foreign bond, depending on recrystallization of the mullite grains for cohesion. The Corning Glass Co. is now casting blocks from molten material for glass tank blocks. These blocks must be cast to exact dimensions, as their hardness prevents chipping. Their porosity is zero, and the rate of corrosion is only about one-third that of fireclay blocks. (Quoted from Ceramic Abstracts, Vol. 7, p. 546 (1928)).

7. **The Whiteware Industry of West Virginia, a Technical Survey**, with descriptive articles on manufacturing processes, by E. K. Koos and Kenneth E. Buck. Research Bull. No. 5, Engineering Experiment Station, W. Va. U. June 1929.

The term "whiteware" in this bulletin includes porcelain and china tableware, white earthen tableware, sanitary ware, floor and wall tile, electrical porcelain, high tension electrical insulators, and refractory porcelain. The number of plants producing various types of ware and annual production are given. The following tables are given: (1) potteries of W. Va. producing whiteware; name of company, location, type of ware produced, number of workers; (2) whiteware production in the U. S.; (3) prices of pottery raw materials; (4) chemical and physical properties of domestic china clays; (5) English china clays; (6) domestic ball clays; (7) wad and sagger clays; (8) chemical properties of feldspars and flints; (9) comparison of domestic production and imports of kaolin and china clays; (10) relative costs of domestic

and imported china clays; (11) summary of W. Va. potteries using foreign and domestic clays; (12) feldspars used in W. Va. potteries; (13) glaze materials used; (14) recipes for vitreous and semivitreous wares; (15) car tunnel kilns used by W. Va. potteries; (16) maturing temperatures and length of firing in periodic kilns; (17) classification of kilns used in W. Va. potteries; (18) import duties on some white-ware. A detailed flowsheet of the manufacture of vitrified hotel china is given. The results of a questionnaire sent to the potteries show that the most serious problems are those of foreign competition and the utilization of waste. (Quoted from Ceramic Abstracts, Vol. 9, p. 292 (1930)).

8. **Ceramic Engineering as a Profession**, by W. A. Koehler. College of Engineering Extension Bull. No. 8, Nov. 1929, also The Ceramic Age, Vol. 15, p. 338-40 (1930).

The meaning of the term "ceramics" is explained by a brief discussion of the various items that come under that term. A review is given of some of the important past contributions by engineers to ceramics, and some of the improvements that may be expected in the future. The importance of ceramics in everyday life is discussed. The article closes with a brief discussion of ceramic education at West Virginia University.

9. **Some Data on the Whiteware Industry of West Virginia**, by W. A. Koehler. Bull. Amer. Ceram. Soc., Vol. 9, p. 57-60 (1930).

Most of the usual types of whiteware are manufactured in W. Va. by 24 different firms. Data are given on the kinds of body raw materials used, and their geographic sources; the materials used for glazes; lawn meshes used; number and kinds of periodic bisque, glost and decorative kilns; number of car tunnel kiln bisque, glost, and decorative kilns; hours kilns are on fire; and the cones reached in each of the various types of whiteware. (Quoted from Ceramic Abstracts, Vol. 9, p. 209 (1930)).

DEPARTMENT OF CHEMISTRY .

1. **Rythmic Bands by Evaporation**, by Earl C. H. Davies. Proceedings of the West Virginia Academy of Science, Vol. 2, p. 1-4 (1928).

A preliminary study has been made of the formation of evaporation rings by four different methods of which two are described for the first time. Experiments include about 40 dyes, 15 other colloids, and a considerable number of other solutions. The object of these preliminary experiments was to find those substances most suited to a study of fundamental laws underlying the formation of rythmic evaporation rings.

2. **Physical Chemistry for Premedical Students**, by Earl C. H. Davies. *Journal of Chemical Education*, Vol. 6, p. 280-283, February, 1929.

This was a contribution to the symposium on "The Teaching of Physical Chemistry," held by Divisions of Physical and Inorganic Chemistry, and of Chemical Education, at the 76th Meeting of the American Chemical Society, September 11, 1928, at Swampscott, Mass.

West Virginia University has been a pioneer in the requirement of physical chemistry for premedical students. The present trend of medicine is toward a fuller appreciation of the necessity for the modern physician to increase his knowledge of this subject.

3. **Rythmic Evaporation Rings of Orange II and Fast Red B**, by Earl C. H. Davies, Kenneth Taylor and E. W. Riblett. *Journal of Physical Chemistry*, Vol. 34, p. 842-854, April, 1930.

These experiments cover more than 100,000 counts of rythmic evaporation rings. The paper includes three sets of curves and six tables. Important conclusions are as follows:

"Pure Orange II solution gives no rythmic evaporation rings when the evaporation containers are perfectly clean.

"Rythmic evaporation rings of Orange II are not due to air or vapors absorbed from the laboratory by the evaporation containers.

"A surface skin of a foreign substance may result in formation of rythmic evaporation rings when the film is not too volatile and is capable of helping to cause the evaporation rings to stick to the surface of the container.

"A thin transparent film of abietic acid on the surface of the evaporation container is a satisfactory foundation film for the formation of rythmic evaporation rings of Orange II.

"When such a foundation of abietic acid is on the surface of the container the number of evaporation rings formed from a given volume of Orange II solution becomes greater (1) as the concentration of the solution decreases, (2) as the temperature of evaporation increases, and (3) as the radius of curvature of the evaporation container decreases.

"With Fast Red B no abietic acid or other foundation film is necessary and the number of evaporation rings becomes slightly less at higher temperatures, whereas concentration and curvature effects are similar to those of Orange II.

"n-Butyric acid lowers the surface tension of Fast Red B and at the same time causes an increase in the number of evaporation rings."

4. **The Chemical Composition of *Andropogon virginicus* and *Danthonia spicata* at Successive Growth Stages**, by R. B. Dustman and

L. C. Shriver. Jour. Am. Soc. Agron. Vol. 21: p. 561-567. May 1929.

The early growth of both grasses shows high protein and low fiber content compared to the later growth stages. Reasonably early, close, and continuous grazing during the spring and early summer months is advisable.

5. Fluosilicates of Some Organic Bases, by C. A. Jacobson and H. A. H. Pray. The Journal of the American Chemical Society, Vol. 50, p. 3055 (1928).

The article records the discovery of five new chemical compounds known by the following names:

1. Di aniline fluosilicate.
2. Di methyl aniline fluosilicate.
3. Di ortho toluidine fluosilicate.
4. Di meta toluidine fluosilicate.
5. Di para toluidine fluosilicate.

The method of making these compounds as well as a discussion of their properties and microphotographs of their respective crystal forms are included in the article.

Specimens of these five new compounds will be found under No. 106104 in the Loeb Collection of Chemical Types of the United States National Museum, Washington, D. C., and are recorded in the 1929 Report of the Museum.

6. Chemical Shorthand Developed, by Louis A. Leslie of New York City and C. A. Jacobson. Two articles published in the October and November 1928 issues of The Gregg Writer.

The new system that was worked out promises to become a real time saver for all stenographers and reporters who take dictations in chemistry, and when the system has been thoroughly mastered it will not only save time but will make for greater accuracy in reporting.

One or two distinctive shorthand characters were ascribed to each chemical compound, and so chosen as to be distinctive for each element or group of elements in the compound. For example, if a stenographer were obliged to write magnesium pyrophosphate, ammonium thiomolybdate or praseodymium orthoaluminate he could do so by two simple characters for each, instead of by four or more rather complex ones.

The lists that were prepared covered the names of thousands of inorganic compounds, yet when the system is complete it will include the characteristic nomenclature in all the different fields of chemistry such as mineralogical, physical, organic, physiological, bacteriological, etc. It will include shorthand characters for the numerous syllables, prefixes, and suffixes found in chemical nomenclature to designate irregular and distinctive atomic combinations.

Obviously a well worked out system of this sort will facilitate the accurate reporting of court proceedings, lectures, letter dictations, etc., where chemical terminology is employed.

7. **Esters of Cyclohexylresorcinol and Paracyclohexylphenol**, by Virgil Greene Lilly and C. E. Garland. The Journal of the American Chemical Society, Vol. 52, p. 2112, (1930).

Considering the excellent germicidal properties of some of the alkyl and aryl substituted derivatives of phenols, and their general low toxicity, some esters, of the salol type, have been prepared using cyclohexylresorcinol and p-cyclohexylphenol, with a hope that they may prove of therapeutic value.

The following esters have been prepared: (1) cyclohexylresorcinol dibenzoate, (2) p-cyclohexylphenol salicylate, (3) o-cyclohexylphenol hydrocinnamate, (4) p-cyclohexylphenol m-nitrobenzoate and (5) p-cyclohexylphenol p-nitrobenzoate.

DEPARTMENT OF DAIRY HUSBANDRY

1. **Cream Line Studies of Market Milk**, by G. Malcolm Trout. Bul. 229 W. Va. Agr. Exp. Station 20 pp. Mar. 1930.
2. **The Effect of Feeding Different Amounts of Calcium and Phosphorus Upon the Growth and Development of Dairy Animals**, by H. O. Henderson and C. E. Weakley, Jr., Bull. 231, W. Va. Agr. Exp. Station. 56 pp., Mar. 1930.

DEPARTMENT OF FARM ECONOMICS

1. **Results of a Regional Replanning Study in the Mountains of West Virginia as Illustrative of the Scope, Methods, and Practical Results of Such Studies**, by Paul A. Eke. The Community as a Unit in Land Utilization. Jour. Farm Econ. Vol. 11: p. 412-421. July 1929.

Forest areas should be located by state authority in non-agricultural areas. Public guidance should be provided in relocating the residents. Forest areas should be purchased by county, state, or federal government wherever private or corporate ownership fails to provide economic forest management.

DEPARTMENT OF FOODS AND NUTRITION

1. **Thyroid Feeding and High Room Temperature**, by Hazel C. Cameron. (Note) Science Vol. 69: p. 576 (May 1929).
A temperature of 96°F. was sufficient to cause death in normal rats as well as in those suffering from vitamin-A deficiency.
2. **Standardization of Cherry and Blackberry Preserves and Blackberry Jelly**, by Hazel Cameron and Ruth Burns. Bull. 234 W. Va. Agr. Exp. Station. 24 pp., June 1930.

DEPARTMENT OF HISTOLOGY AND EMBRYOLOGY

1. **An Abnormal Human Embryo 11 mm. Long**, by G. S. Dodds. *Anat. Rec.*, Vol. 43, p. 199 (1929).

The paper describes a peculiar human embryo, presented by Dr. G. R. Maxwell of Morgantown, W. Va., which, as indicated by size and structure was about six weeks old. The trunk region, both in external and internal structure, was about normal. The head was decidedly abnormal, having the general shape of a cylindrical extension of the body. Branchial arches and grooves, which should show plainly at this age, are wanting. The mouth has the form of a wide, shallow depression and the nasal pits are represented by a single opening far forward in the head. The internal cavities connecting with mouth and nostrils are of very unusual form. The brain shows all the usual parts, but is more slender than usual and the flexures are less pronounced. The cranial nerves, are for the most part of the usual form, but they show certain peculiarities of structure and distribution.

DEPARTMENT OF HORTICULTURE

1. **The Use of Performance Records in Laying Out a Raspberry Fertilizer Experiment**, by M. B. Hoffman. *Proc. Am. Soc. Hort. Sci.* Vol. 26: p. 203-207. 1929.

Trustworthy results may be expected from the use of a 30-foot single-row plot.

2. **Factors Affecting Fruit Setting in the Apple**, by H. E. Knowlton. *W. V. U. Scientific Society Bulletin* 2: p. 46-56. Oct. 1928.

A variety of apple is "born" with a certain genetic complex, upon which the various environmental factors play.

3. **Some Recent Results in Apple Sterility Studies**, by H. E. Knowlton. *Proc. Am. Soc. Hort. Sci.*, Vol 26,p. 62-64. 1929.

Stayman will not fertilize Delicious, but York, Grimes, and Golden Delicious are good fertilizers for it. Stayman, Winesap, and Mammoth Black Twig are not only self-sterile but of little value as pollenizers for other varieties because of the impotent pollen they produce.

4. **The Effect on Yield of Sprout Removal from Potato Seed Tubers**, by K. C. Westover. *Proc. Am. Soc. Hort. Sci.*, Vol. 25: p. 53-57. 1928.

The practice of removing sprouts from improperly stored potato seed stock increases the loss in storage from decay, reduces the stand of plants in the field and lowers their vigor, and decreases the yield of prime tubers and the total yield.

DEPARTMENT OF MECHANICS

1. **Qualifications for Engineers**, by G. P. Boomsliter. Extension Bulletin No. 8, W. V. U. College of Engineering. Nov. 1929.

A published radio talk which analyzes the activities of the engineer in various branches of engineering and discusses the qualities needed to successfully carry out these activities. It gives the opinions of engineers as to the necessary qualities for a successful engineering career and shows how college training in engineering strengthens these qualities. It also lists those qualities which will enable a boy to successfully complete a college course in engineering.

2. **Wire Rope in Coal Mines**, by G. P. Boomsliter. Special Report Am. Soc. Mech. Eng. Oct. 1929.

This is a study of the use of wire rope in coal mines. It gives a list of 99 coal mines and of the depth of shaft, maximum load hoisted, maximum hoisting speed and acceleration, kind of power and factor of safety of the wire rope. It contains the result of a questionnaire on the use of wire rope which includes size of sheave, size and kind of grooves in the sheaves, methods for prolonging life and practical criteria on which to discard wire ropes as worn out.

DEPARTMENT OF MACHINE DESIGN AND CONSTRUCTION

1. **Mechanical Engineering as a Profession**, by Leslie D. Hayes. Extension Bulletin No. 8, College of Engineering, p. 36-41. Nov. 1929.

This talk describes briefly how the work of the mechanical engineer has woven itself into the everyday life of the people since the invention of production machinery late in the eighteenth century. It shows how the further growth of the fields of civil, electrical, mining, chemical and industrial engineering are interlocked with the progress in mechanical engineering, and points out the service which it should render to the people of West Virginia through the development and use of the tremendous power resources of the state.

DEPARTMENT OF MINING ENGINEERING

1. **Some Important Uses of Coal**, by Charles E. Lawall. Proceedings of the W. Va. Academy of Science, Vol. 2, p. 96. (1928).

This paper discusses the importance of coal as a raw material for use in manufacturing a whole series of by-products, including coal tar, and its derivatives and the possibilities of using it for the manufacture of fuel oil. It stresses the importance of processing West Virginia coals in the state as far as possible so that West Virginia may get the most benefit from the most important of its natural resources.

2. **Why Need for Technical Training of Men in Coal Industry is Pressing**, by Charles E. Lawall. Coal Age, Vol. 34, p. 23, 1929.

This article emphasizes the importance of training young mining engineers for the coal industry. The coal industry has grown from a desultory business during the past decade to a highly competitive business and is more and more offering opportunities to trained technical men, and ways are suggested in the paper as to how the bituminous coal industry might attract promising young engineers to this industry.

3. Mining Education in West Virginia High Schools, by Charles E. Lawall. Mining and Metallurgy, Vol. 10: p. 232. 1929.

This paper outlines the work of teaching mining courses in several high schools in West Virginia. The School of Mines of West Virginia University in cooperation with two high schools of the state tried the innovation of teaching mining courses in these high schools with the object of adapting high school vocational courses to the industrial needs of mining communities and this experiment has resulted in the teaching of mining in many other high schools. The method of conducting these courses is outlined in this paper.

4. School of Mines of West Virginia University, by Charles E. Lawall. Mining Congress Journal, Vol. 15: p. 799. 1929.

This paper described the work of the School of Mines at West Virginia University. It was one of a series of twelve articles describing various Schools of Mines throughout the United States. The paper is illustrated and describes the facilities and equipment of the Mining Engineering Department.

5. Mining Education in West Virginia, by Charles E. Lawall. West Virginia State Safety Day Publication, September 1929, p. 10.

This article describes the work done by the Mining Engineering Department, Mining Extension Department, Bureau of Mine Research and the Graduate Research work done at the School of Mines of West Virginia University.

6. Mining Methods in West Virginia, by Charles E. Lawall, Ivan A. Given and Harry G. Kennedy. Research Bulletin No. 4 of the Engineering Experiment Station of West Virginia University, 1929.

It describes the various methods of mining coal used in West Virginia together with tables showing the performance records of the different systems in various mines. There is also included in the bulletin a history of coal production in West Virginia together with the geology of each district.

DEPARTMENT OF PHYSICS

1. Two Lecture Demonstrations in Physics, by R. C. Colwell and M. C. Holmes. (Note) Nature, Vol. 122, p. 205, 1928.

2. **Fading Curves Along a Meridian**, by R. C. Colwell. *Proceedings of the Institute of Radio Engineers*, Vol. 16, p. 1570, 1928.
3. **Fading Curves and Weather Conditions**, by R. C. Colwell. *Proceedings of the Institute of Radio Engineers*, Vol. 17, p. 143, 1929.
4. **Action and Reaction in Rotary Motion**, by R. C. Colwell, (Note) *Nature*, Vol. 122, p. 962, Dec. 22, 1928.
5. **Weather Forecasting by Signal Radio Intensity**, by R. C. Colwell. *Proceedings of the Institute of Radio Engineers*, Vol. 18, p. 533, 1930.

DEPARTMENT OF PHYSIOLOGY

1. **The Effect of Anoxemia on Hunger Contractions**, by Edward J. Van Liere and George Crisler. *American Journal of Physiology*, Vol. 93, No. 1, p. 267, 1930.

Dogs were trained to lie quietly in the same position for three or four hours and were taught to swallow a small rubber balloon with a rubber tube attached so that hunger contractions could be recorded by connecting the tube with a water manometer, the rider of which wrote on a smoked drum.

Anoxemia was produced by the use of a nitrous-oxide oxygen apparatus; it was arranged so that oxygen could be diluted with nitrogen and the amount of the former could be regulated at will. A Kunde muzzle was put on the animal and it was connected with the above described apparatus; a flutter valve was inserted, however, so that the animal expired into the open air. The stomach tube was passed through the muzzle by means of a specially made opening.

The animals were starved for 24 or 48 hours and control hunger contractions were recorded under normal oxygen tension, that is, about 20 percent oxygen. Different degrees of anoxemia were then produced; the lowest oxygen pressure used was approximately 5 percent. This degree of anoxemia corresponded to a height well over 30,000 feet, that is considerably higher than Mt. Everest. Unacclimated dogs could withstand this degree of anoxemia for only a very short period of time.

The conclusions drawn from these experiments were that gastric tone is increased at an oxygen tension of 10 percent or less and that it varies directly with the degree of anoxemia. At 8 percent oxygen tensions or less the hunger contractions diminish in height; they persist, however, to as low an oxygen tension as the unacclimatized animal can withstand which is about 5 percent. The problem suggests that changes in the central nervous mechanism are responsible for the loss of hunger in mountain sickness.

DEPARTMENT OF PLANT PATHOLOGY

1. **Inactivation of the Tobacco Mosaic Virus by High Pressures**, by N. J. Giddings, H. A. Allard, and B. H. Hite. *Phytopath.*, Vol. 19: p. 749-750. 1929.

High pressures were effective in destroying or inactivating the virus of tobacco mosaic.

2. **Comparative Value of the Size of Phytophthora Sporangia Obtained Under Standardized Conditions**, by L. H. Leonian and Herbert L. Geer. *Jour. Agr. Res.* Vol. 39: p. 293-311. 1929.

The size factor cannot be of primary importance in taxonomy. Hartley's organisms Nos. 8, 36 and 121 are sufficiently different from all others to merit further study in their native habitat to determine whether they should be described as new species.

3. **Studies on the Variability and Dissociations in the Genus Fusarium**, by L. H. Leonian. *Phytopathology*, Vol. 19: p. 753-868. 1929.

A certain specific line of behavior persists throughout all of the strains and variants of a given fungus species. The path of the species may run in a zigzag line, but it does not exceed the specific orbit.

DEPARTMENT OF POULTRY HUSBANDRY

1. **The Variation in the Weight and Number of Eggs and the Weight of White Leghorn Fowls During the First Two Years of Production**, by Horace Atwood. *Poultry Science*, Vol. 8: p. 51-53. 1928.

Decreases from first to second year were 20.1 percent for number of eggs and 14.4 percent for weight of eggs. Increase in average weight of eggs the second year was 7.36 percent, and increase in weight of birds during second year was 15.3 percent compared to weight during first year.

2. **Observations Concerning the Time Factor in Egg Production**, by Horace Atwood. *Poult. Sci.* Vol. 8: p. 137-140. Mar. 1929.

The longer the cycle the shorter are the intervals between the laying of successive eggs. The intervals between egg-layings about the middle of the cycles are shorter than the intervals at either extremity. The shorter average intervals are usually associated with the more prolific layers.

3. **Further Studies on Factors Influencing the Weight of Eggs**, by Horace Atwood and Thomas Clark. *Poultry Science*, Vol. 8, p. 193-197. May 1929.

Kamala should not be given while birds are in full production, since undesirable effects may result in at least some cases.

4. **A Study of the Time Factor in Egg Production**, by Horace Atwood. Bull. 223, W. Va. Agr. Exp. Station. 12 pp. Oct. 1929.
5. **The Relationship Between the Number and Weight of Eggs and Body Weight of Leghorn Fowls During the First Three Years of Production**, by Horace Atwood and T. B. Clark. Bull. 233 W. Va. Agr. Exp. Station. 20 pp. Apr. 1930.

DEPARTMENT OF SANITARY ENGINEERING

1. **Pollution in the Monongahela River Basin and Its Effect On Public Water Supplies**, by L. V. Carpenter. Technical Bulletin No. 2, West Virginia University, Engineering Experiment Station, p. 27-38, 1928.

An estimate of the total amount of pollution entering the Monongahela River, with tabulations of bacteriological and pH determinations made above and below Morgantown to show the effect of acid mine waters on the sterilization of sewage wastes. Suggestion is made that the quantity of acid is not sufficient to kill bacteria but inhibits the growth. Court decisions on the discharge of mine waters are cited.

2. **Use of Artificial Turbidity for Algae Control**, by L. V. Carpenter. (Note) Eng. News Record, Vol. 101, p. 852. 1928.

The addition of clay to clear water to increase the turbidity so as to settle the algae in the coagulating basin was practiced at Huntington, W. Va., and Evanston, Illinois. When sufficient clay was added to give an artificial turbidity of 50-75 p. p. m., normal filter runs could be obtained.

3. **Do You Know Your Water Supply**, by L. V. Carpenter. Radio talk delivered over WMMN July 28, 1929, published in the Morgantown Post July 29, 1929.

Methods of treating wells, springs and small supplies of water for the camper as well as the general principles governing the larger supplies are discussed in non-technical form.

4. **Report on Pollution Survey of Cheat River Basin**, by L. V. Carpenter and L. K. Herndon. Bulletin No. 1, State Water Commission, Nov. 1929.

The various waste waters causing pollution have been fairly accurately recorded on a watershed of 1400 sq. mi. A detailed study of the wastes from a tannery is given. Data on the sewage from various towns are tabulated. Weir measurements and estimates of quantity of drainage from the mines on the watershed as well as results of stream surveys to show the effect of these wastes are given. Data collected on Lake Lynn shows the amount of acidity and dissolved oxygen at

great depths. Standard methods to be used in stream pollution surveys in West Virginia are given.

- 5. Sanitary Engineering as a Profession**, by L. V. Carpenter. A radio talk delivered December 2, 1929. Extension Bulletin No. 8, West Virginia University, Engineering Experiment Station, 1930.

An outline of the principal works that a sanitary engineer performs together with a number of the requirements of a good sanitary engineer, the possibilities of employment in the profession, and the importance of the sanitary engineer to the country.

- 6. Report on Proposed Improvements to Morgantown Water Supply**, by L. V. Carpenter. Published in mimeographed form January 30, 1930, by Morgantown City Council. 46 pages (University Library).

Detailed report with cost analysis of six different possible water supplies, results of zeolite softening tests and comparison of water rates and population studies.

- 7. Demonstrating Proposed Treatment by Means of Miniature Plant**, by L. V. Carpenter, *Water Works Eng.*, Vol. 83, No. 6, p 351-2 (1930).

Brief outline of the water problem in Morgantown with descriptions of the models used in suggesting the effect of proposed methods of softening and elimination of tastes and odors.

DEPARTMENT OF STRUCTURAL ENGINEERING

- 1. Report of the Committee on Iron and Steel Structures**, by R. P. Davis, et al. Bulletin No. 314, American Railway Engineering Association, February, 1929.

This report covers specifications for steel highway bridges, electric welding of connections in steel structures, uses of copper bearing steel for structural purposes, effect of dead load on impact from moving loads on bridges, and reamed work.

- 2. Report of the Committee on Iron and Steel Structures**, by R. P. Davis, et al. (Member of Committee). Bulletin No. 322, American Railway Engineering Association, December, 1929.

This bulletin discusses the use of copper bearing steel for structural purposes, impact on railway bridges, bearing values of large rollers and longitudinal forces on bridges.

- 3. Civil Engineering as a Profession**, by R. P. Davis. Extension Bulletin No. 8, College of Engineering, West Virginia University, November, 1929.

This paper contains a number of radio talks by members of the

instruction staff of the College of Engineering, West Virginia University. The talk on Civil Engineering as a Profession covers the historical developments of civil engineering, and describes in some detail the scope of the work of the civil engineer, which includes geodesy and surveying, railway engineering, highway engineering, hydraulic engineering, water supply and sanitary engineering, structural engineering and valuation engineering. The paper also describes the curriculum in civil engineering as given at the West Virginia University.

DEPARTMENT OF ZOOLOGY

1. **The Influence of Pineal Feeding Upon the Rate of Metamorphosis in Frogs**, by John Addair and F. E. Chidester, *Endoc.* Vol. 12, No. 6, pp. 791-796, 1928.

Pineal hastens the rate of metamorphosis, much in the same manner as thyroid does, but is not so powerful as thyroid in this respect. Furthermore, if the feeding of the pineal is discontinued, development slows up. Resumption of pineal feeding results in a sudden speeding up of the rate of metamorphosis.

2. **Influence of Thyroid Extract and Iodine on Growth and Development, I. With a Standard Basic Diet**, by F. E. Chidester and W. M. Insko, *Jr. Am. Nat.*, Vol. 62, pp. 554-558, 1928.

Rats and rabbits were placed on a standard basic diet, and certain lots were given glucose, KI, and thyroid extract, respectively. Glucose retarded weight decrease otherwise occurring under heavy iodine feeding. Fat deficiency in the diet was evident, even in the presence of sufficient minerals, and the vitamins. Iodine influence on metabolism was demonstrated.

3. **The Influence of Minute Doses of Iodine and Iron on Growth of Rats Furnished Vitamin A-free Diet**, by F. E. Chidester, A. G. Eaton and G. P. Thompson. (Note) *Science*, Vol. 68, No. 1766, p. 432, 1928.

Fifty-seven rats were placed on an experiment in which iodine and iron were used to cure xerophthalmia and protect them from Vitamin-A deficiency. The minerals apparently acted as catalyzers of importance in releasing stored foods. The studies are being continued through 1929 and 1930.

4. **The Influence of Arsenic, Ferrous Sulphate and Copper Sulphate on Rats Furnished a Vitamin-A Free Diet With Iron Added**, by F. E. Chidester and A. G. Eaton. *Proc. Soc. Exp. Biol.*, Vol. 26, pp. 141-142 (1928).

Arsenic, iron and copper in minute doses seem less effective than the combination of iron and iodine previously shown by the writers to be of benefit in Vitamin-A deficiency.

- 5. The Influence of a Modified Fowler's Solution of Arsenic on Rats Receiving Vitamin A-Free Diet with Iron Iodide Added,** by F. E. Chidester, A. G. Eaton and G. P. Thompson. *Proc. Soc. Exp. Biol.*, Vol. 26, pp. 143-144, 1928.

Fowler's solution of arsenic in doses of 0.379 mg. daily, was used in combination with iodide of iron in an experiment to determine their effect on Vitamin-A deficient rats. Rapid declination in weight indicated the probable digestive disturbance due to arsenic in the presence of iron.

- 6. Influence of Desiccated Thyroid and Iodine on Growth. II. With a Standard Acid Diet,** by F. E. Chidester, A. G. Eaton and W. M. Insko, Jr. *Am. Nat.* Vol. 63, pp. 239-247, 1929.

Twenty-eight rats and six rabbits were used in experiments on the influence on growth of thyroid extract and iodine with a standard acid diet.

In the rabbits, glucose apparently protected the animals somewhat from the usual iodine effects. In the rats, low dosage of thyroid favored pregnancies in all cases and did not cause resorption of the young. Minute doses of thyroid induced growth of bones and increased weights. Glucose, administered with the iodine, accelerated this gain.

- 7. The Influence of Suprarenal Cortex and Medulla on the Growth and Maturity of Young (White Leghorn) Chicks,** by A. G. Eaton, W. M. Insko, G. P. Thompson and F. E. Chidester. *Am. Jour. Phys.*, Vol. 88, No. 2, pp. 187-190, March 1929.

Fifty white leghorn chicks, when twelve days old, were divided into three groups and placed under experiment for eleven weeks to determine the influence of feeding desiccated suprarenal medulla and cortex, in addition to a standard or balanced ration. Males receiving desiccated suprarenal cortex matured more rapidly as indicated by the weights of the tests. Their body weights, like those of the females in the cortex group, nearly equalled the controls.

Chicks fed suprarenal medulla grew less rapidly than the controls or the cortex group, and the weight of the tests fell far below controls and cortex group.

- 8. The Influence of Desiccated Suprarenal Cortex and Medulla on the Growth and Maturity of Young Rats,** by F. E. Chidester, A. G. Eaton and G. P. Thompson. *Am. Jour. Phys.*, Vol. 88, No. 2, pp. 191-194, 1929.

Desiccated suprarenal cortex induces earlier sexual maturity in young female rats than does suprarenal medulla.

- 9. A Starfish Attempts to Ingest a Minnow,** by F. E. Chidester. (Note) *Science*, Vol. 70, No. 1818, p. 428-429, 1929.

A starfish (*Asterias forbesii*) was observed in the act of ingesting the head of a full grown salt water minnow, 10 cm. in length. The cardiac stomach was protruded 2 cm. along the head of the fish.

NEW BOOKS AND BOOK REVIEWS

Published in 1928-1930.

COLLEGE OF AGRICULTURE

1. **THE PLANT RUSTS (Uredinales)**, by J. C. Arthur, C. R. Orton and F. D. Fromme et al. A book of 446 pages, published by John Wiley & Sons, Inc., 1929.

This book gives a complete account of the biology of the rust fungi up to 1928, including bibliographical references.

2. **DAIRY CATTLE FEEDING AND MANAGEMENT**, (Second Edition), revised by H. O. Henderson. Previous authors: C. W. Larson and F. S. Putney. Pages VII-XXIII+450. With numerous tables, cuts and bibliographical references. 1928. John Wiley & Sons, New York.

During the eleven years since the first edition was published, the science of dairying has advanced rapidly. This is especially true in the fields of nutrition, pathology, and genetics. The object has been to bring together in a teachable way the more important findings of investigators in the field of dairy husbandry. Although the book was written primarily for the student in dairy cattle feeding and management, it was intended that the lectures might be used as a reference and a helpful guide by practical dairymen, herdsmen and teachers.

COLLEGE OF ARTS AND SCIENCES

1. **PHYSICAL CHEMISTRY FOR PREMEDICAL STUDENTS**, by Earl C. H. Davies, Associate Professor of Chemistry, Second Edition, revised and enlarged. 236 pages, 46 illustrations, and 67 tables. Published in mimeograph form by Edwards Brothers in 1928.

The book contains the latest developments in this rapidly growing field, including numerous references to the most recent literature. It is believed that the first edition was the first American text in Physical Chemistry, designed especially for premedical students.

2. **A CHEMICAL DICTIONARY**, by Ingo W. D. Hackh, 790 pages. Reviewed by C. A. Jacobson, Professor of Chemistry. *Journal of Chemical Education*, Vol. 7, No. 3, page 721-3, 1930.

The review points out the scope and character of the book, and calls attention to several omissions of chemical words and names of noted chemists. It mentions some errors in definition and inconsistencies in nomenclature and pronunciation, but gives Professor Hackh credit for having produced "the best and most serviceable dictionary of its kind in the English language."

Professor Hackh wrote the following under date of March 4, 1930: "Dear Doctor Jacobson: I thank you most heartily for your

review of the Chemical Dictionary in the Journal of Chemical Education. This has been the most constructive review which I have seen."

- 3. OUTLINES OF ECONOMIC ZOOLOGY**, by Albert M. Reese, Professor of Zoology, 3rd edition, 323 pp. Published by P. Blakiston's Son & Co., Philadelphia, 1930.

An elementary textbook of zoology, discussing animals almost entirely from the economic standpoint.

COLLEGE OF ENGINEERING

- 1. TIMBER DESIGN AND CONSTRUCTION**, by H. S. Jacoby and R. P. Davis, 2nd Edition, 346 pages, published by John Wiley & Sons, 1930.

This book contains the digested results of extensive experimental investigations on fastenings used in framing, including bolts, nuts, washers, spikes, nails, screws, dowels, pins, keys and metal straps and plates. All types of joints used in framing are described. The design of wooden beams and columns is covered and examples worked out. A complete design of a wooden roof truss is made. Many examples from practice of timber structures are illustrated. The methods of commercial grading, the testing of timbers and unit design and stresses are discussed.

- 2. DESCRIPTIVE GEOMETRY**, Part I, in mimeographed form, Copyrighted 1929, by Leslie David Hayes, M. E., Professor of Machine Design and Construction, and George Walter Grow, M. S., Assistant Professor of Drawing and Machine Design at West Virginia University.

This new textbook covers the subject from the standpoint of the draftsman. It takes the simple problems of orthographic projection, already familiar in mechanical drawing and from these derives the laws which govern all orthographic projection work. The laws are stated in thirty-four theorems with opportunity for their complete geometry proof. Great care has been taken to state these laws in such a manner that the usual large number of exceptions and special solutions have been avoided.

The book covers the work now taught in the College of Engineering of West Virginia University. It is prepared on the mimeograph and bound with manila cover. The additional chapters for the completion of the book are in preparation.

SCHOOL OF MEDICINE

- 1. THE ESSENTIALS OF HUMAN EMBRYOLOGY**, by G. S. Dodda. Pages vii+316. 182 illustrations. John Wiley & Sons, New York, 1929.

The book is essentially a human rather than a comparative embryology. The author has tried to include those facts about human development which are most useful in rounding out a knowledge of adult human structure, and in giving an understanding of the relation between mother and unborn child. It has been the aim throughout to present the embryo not merely as a human being in the making, but also as a living individual with all the life activities of other living beings. The book aims at simplicity of treatment, compressed within as brief a space as is consistent with completeness. The illustrations are designed to explain and amplify the text, and are labeled in full.

West Virginia University Bulletin

SERIES 31

No. 2

BULLETIN OF THE WEST VIRGINIA UNIVERSITY SCIENTIFIC ASSOCIATION

Vol. 2, No. 4



1930

August One, Nineteen Hundred Thirty
Published by THE UNIVERSITY
MORGANTOWN, WEST VIRGINIA

Entered as second-class matter, July 15, 1929, at the postoffice at Morgantown,
W. Va., under act of August 24, 1912.

Issued twice in October, December, February, April, and June, and once
in each other month.

BOUND

NOV 13 1947

UNIV. OF MICH.
LIBRARY

